MFN 113

FOOD PROCESSING ANDPRESERVATION TECHCNOLOGY

BLOCK-1 INTRODUCTION, PHYSICAL AND CHEMICAL PRINCIPLES IN FOOD PROCESSING

Block 1 deals with the physical and chemical principle used in food processing and various Indian crops grown like wheat, barley, maize rice pulses jute and coffee, their production and storage conditions. storage conditions include traditional storage and modern storage techniques. It comprises of III units. Unit-I. Main crops grown in the country their importance and storage. Unit II. Comprises of Physical principles in food processing operations, Thermal Processing-Degree of processing of preservation. Selecting heat treatments, heat resistance of microorganisms. nature of heat transfer, protective effects of food constituents, and types of thermal treatments. Refrigeration - Refrigeration, cool storage and shelf life extension; cool storages with air circulation, humidity control and gas modification (ie.CA, MA, & SA), Dehydration – Dehydration, water activity and food safety/quality, methods of dehydration, lionizing radiations - Forms of radiant energy; ionizing radiations, sources and properties; radiation units; radiation effects. Limiting indirect effects; dose fixing factors. Unit III. Chemical principles in food processing: Preservation/processing by sugar, salt, curing, smoke, acid and chemicals; chemical changes in foods that affect texture colour, nutritive value and safety during handing, storage and processing; Chemical and biochemical reactions affecting food quality and safety, flavor.

UNIT I - INTRODUCTION: MAIN CROPS GROWN IN THE COUNTRY – IMPORTANCE AND STORAGE

STRUCTURE

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1.2: India's Major Crops
- 1.2.1 Rice
- 1.2.2 Wheat
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1.3 Traditional storage technologies/Low-cost storage technologies
1.4. Improved/ Modern storage methods/ High cost storage technologies
1.5. Controlled atmosphere storage
1.6. Modified atmosphere packaging:
1.7. Hypobaric Storage / Low-Pressure Storage:
1.8. Conclusion

OBJECTIVES:

After studying this unit learners will be able to know about:

i. To know the major crops of India and its production.
ii. To get the knowledge about the traditional storage technologies
iii. To acquaint with Low-cost storage technologies

1.1 INTRODUCTION:

Learners will gain knowledge of the many crops farmed in the country in this unit. A group of plants raised for commercial purposes make up the crop. These plants are purposely developed to achieve particular aims or objectives. The crops are further categorized or classed to comprehend plant protection, breeding programmes, and even aggregation for gauging production and distribution status. Primary temporary crops and primary permanent crops are the two main categories into which agricultural crops were divided by the Food and Agriculture Organization (FAO) of the United Nations. The term "Primary" in this context refers to those who were reared inland and don't go through any first screening. As a result, these crops retain all of their biological characteristics. Agricultural fields are used to plant and harvest the primary temporary crops.

The crops classified as Primary Permanent crops include fruits and berries, nuts, oil-bearing crops, spices, condiments, aromatic herbs, and plantation crops including tea, coffee, and rubber. The crops are combined based on one or more characteristics that all other crops under consideration share. The crops classified as "coarse cereals" by the Ministry of Statistics and Programme Implementation (MOSPI), Government of India, include rice, wheat, sorghum, maize, and ragi minor millets. These cereals and the pulses collectively are referred to as "food grains". In addition to these food grains, other crops are classified as fruits and vegetables, sugar, cotton and jute, plantation crops (tea, coffee, and rubber), spices, condiments, and aromatic plants, flower crops, etc.

The aforementioned crops are further divided into "food crops" and "nonfood crops," which is an important classification. The annual succession and spatial organization of the crop(s) and fallows on a certain region is known as the cropping pattern. It is the percentage of the unit area that is currently covered by different crops.

This unit also gives details about various storage structures classified into two categories, i.e., traditional storage/low-cost storage technologies and improved methods/ modern methods /high-cost storage technologies. Traditional storage structures can be beneficial for farmers needing a small-scale storage system. These systems include in-situ storage, sand and coir, clamps, pits, cellars, ventilated storage, and evaporative cooling. On the other hand, modern methods include refrigerated storages like cold storages, environment-controlled storage (controlled atmospheric storage), modified atmosphere storage, and hypobaric storage. All the storage methods are equally important and can provide high revenue to the farmers and food industries.

India holds the second position in horticultural crop production globally, producing vegetables, fruits, coffee, cotton, and spices in large quantities. A large portion of such products is lost owing to bad storage practices, insects, and pests. The post-harvest losses associated with fruits and vegetables have been put in the range of 6-18%. Appropriate storage environment can improve the quality and marketability of horticultural produce. To obtain a suitable atmosphere for the produce, advanced provisions like temperature, air circulation, and relative humidity (RH) control could be made. Also, the composition of air in the storage area could be regulated. Storage spaces can be classified based on the requirement of refrigeration, i.e., those requiring refrigeration and those that do not. Clamps, ventilated structures, cellars, and evaporative cooling chambers are some conventionally used low-cost traditional storage structures. On the other hand, cold or refrigerated storage, modified atmospheric packaging (MAP), controlled atmospheric storage (CAS), hypobaric storage etc are modern storage techniques used in large industries that provide more effective storage facilities. For developing countries like India, both types of structures stand equally important.

1.2 INDIA'S MAJOR CROPS

The names of some of the different fruits, vegetables, and crops that are grown in India are as follows: Cereals for food are Wheat, Rice, Jowar, Ragi and Bajra (millets) and Sorghum. Spices are Cardamom, Nutmeg, Mace, Ginger, Garlic, Turmeric, Dry Chilli Peppers, Coriander, and Anise. Seeds and pulses include Cotton seed and lint, Sesame seeds, Safflower seeds, Castor oil seeds, Pulses, Lentil, Fennel. Vegetables include Lemons, Chickpeas, Okra, Cauliflower, Green Peas, Pumpkin, Potatoes, Gourds, Tomatoes, Cabbage, Onions, Dry Beans,; Limes; Pigeon Peas; Brinjal; Beverages o Tea o Coffee

1.2.1 Rice

Rice is India's primary food grain. The nation comes in second place globally in terms of rice output. Approximately 34% of the nation's total cropland is dedicated to the production of rice. 42% of the nation's total food crop production is made up of rice. The fields used for rice production must get a minimum of 125 cm of precipitation annually. Additionally, it is essential that the area's average temperature remain at 23 °C. Rice is farmed in both the eastern and western parts of India. shoreline areas, Northeast India, and the drainage basin of river Ganga. The important rice growing states in India are as follows:

- Punjab
- West Bengal
- Uttar Pradesh

Other than these states, rice is cultivated in the following states of India:

- Karnataka
- Tamil Nadu
- Haryana
- Orissa
- Chhattisgarh
- Bihar
- Maharashtra
- Assam

1.2.2 Wheat

The second most important food grain cultivated in India is wheat. The Rabi season is the ideal time to grow wheat. The Green Revolution in India paved the way for a substantial development in wheat production in the nation. Since the revolution, the production of the second most important food crop has risen considerably. The elements that contributed to increased wheat production are better seeds, right usage of water supply, and manures. In India, wheat is grown in regions which receive a mean precipitation of 75 cm. The region should also have productive soil. The state of Uttar Pradesh ranks first in terms of wheat production. About 35% of the overall wheat production is done by the state. Other than Uttar Pradesh, states like Haryana and Punjab also produce a significant amount of wheat.

1.2.3 Jowar

Jowar is a major food grain in India as well. The ideal climate for cultivation of Jowar should be warm and arid and the average annual rainfall should be 45 cm.

The state of Maharashtra is the leading producer of Jowar in the country. The state houses about 50% of the overall area for Jowar production in India. Maharashtra cultivates about 52% of the overall Jowar production in the country. Other important producers of Jowar include states like Andhra Pradesh, Karnataka, and Tamil Nadu.

1.2.4 Pulses

Pulses are cultivated in the arid areas of the country. These harvests supply nitrogen to the earth. The population of India prefers a diet which contains pulses since they carry a significant degree of proteins. The top producer of pulses in India is the state of Madhya Pradesh. The state contributes 24% of the overall pulses production of the nation. Other major pulse producing states include Rajasthan and Uttar Pradesh.

1.2.5 Jute

India is a prominent jute producing nation across the world. Some of the important jute producing states in the country are Bihar, West Bengal, and Orissa. A negligible amount of jute is produced in Uttar Pradesh and Assam.

1.2.6 Coffee

The states of Kerala, Karnataka, and Tamil Nadu are the major coffee producers in India. They house a number of coffee estates and farms in Southern India. Indian coffee is famous for its flavor and aroma. As a result, it has a significant demand in the global coffee market. India is a major exporter of coffee because of this. The Nilgiri Mountain Ranges produce coffee on a substantial scale.

1.2.7 Rubber

Rubber is a tree crop which is grown in agricultural estates. It is made from latex which is emitted from the stems of the plants. The ideal weather for rubber growing is a warm and moist weather and the soil should be sufficiently watered. The following states are the important cultivators of rubber in India: Karnataka, Kerala, Tamil Nadu

Kerala ranks as the top most producer of rubber in the country. Most of the horticultural crops are seasonal, having a relatively short harvesting season, and most of them are highly perishable. Hence, proper storage of the horticultural crops using appropriate methods would prolong their availability.

1.3 TRADITIONAL STORAGE TECHNOLOGIES/LOW-COST STORAGE TECHNOLOGIES

Some of the low-cost storage structures have been discussed below:

1.3.1. In situ/ on-site/ field storage: The process of on-site storage entails delaying crop harvest by letting it remain in the ground. Until there is a market need, the crop is left in the land. The majority of crops grown as roots, rhizomes, or tubers use this technique. The fact that the area where the food is grown is still occupied and new crop planting may take longer using this method is a significant drawback. This is very comparable to certain fruits that have been left on the tree. Crops should be safeguarded against attacks from pests and diseases, as well as damage from chilling and freezing.

1.3.2. Sand and Coir: Sand and coir are traditionally used in India as a storing method for potatoes. This approach allows the produce to be kept for extended periods of time.

1.3.3. Pits: Pits are trenches where a cavity has been excavated. According to Rees et al. (2012), the interior of these dug holes or cavities is lined with cut grass, wood chips, sand, stubble, or soil (Figure 1). They are prepared along the field's edges and at a high position where there is a likelihood that the cultivated field will accumulate less rain (El-Ramady et al., 2015). Due to its submersion in the pits, the product maintains a colder temperature than the surrounding air. Until there is a market demand for the crop, tubers including potatoes, carrots, sweet potatoes, onions, turnips, parsnips, cabbages, and beets are covered with straw and dirt.

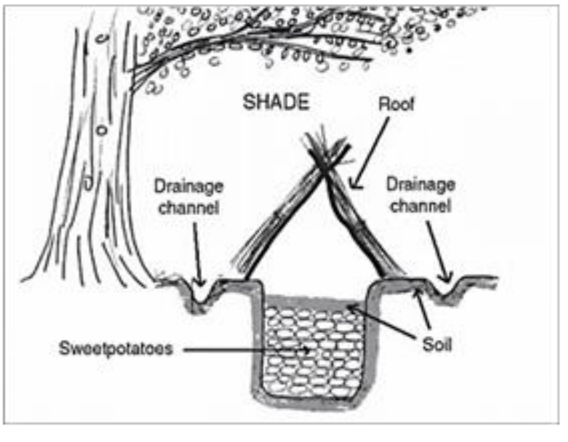

Figure1.Pitstorageforpotatoes(adaptedfromRees*et al.*, 2012)

1.3.4. Clamps: In several regions of the world, clamps have long been used to store potatoes (Figure 2). Usually, a clamp is constructed near the field's boundary. It is between one and two metres wide. The proportions are marked after the potatoes are piled in conical heaps. On bare ground, a bed for the potatoes is frequently constructed using straw. The angle of repose of the heap determines its middle height, which is approximately one-third of the clamp's diameter. The straw is bent at the top to avoid possible rotting, and rain pours through it as it passes over the building. The compressed straw must be between 15 and 25 cm thick.

After two weeks, the soil is deposited over the clamp to a depth of 15-20 cm, depending on the local climatic conditions (El- Ramady et al., 2015; Elansari et al., 2019). In India's more tropical temperatures, more straw has been utilised in place of soil to improve ventilation. The creation of a second layer of insulation using dirt and straw is also possible when the ambient temperature is very low. To provide sufficient ventilation, chimney-style air vents might be built in places with high ambient temperatures near the top of the clamp. Building the clamp under a tree or a roof will prevent rainwater from entering the clamp in locations that experience severe rainfall (Kale et al., 2016).

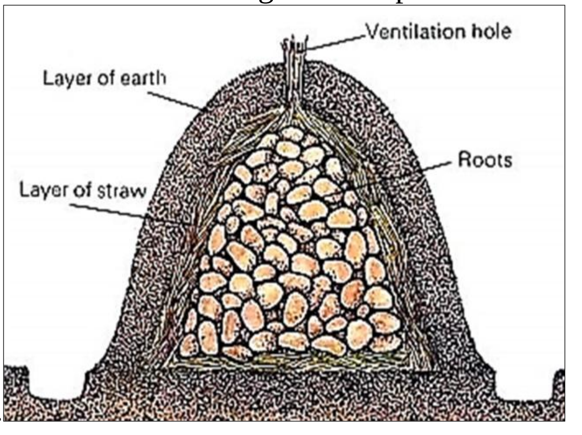

Figure2.Rootclampcross-section(adaptedfromKale*et al.*, 2016)

1.3.5. Cellars/ Root cellars: The cellar (Figures 3a and 3b) is an additional illustration of the conventional storage arrangement. Ideally, cellars should be dim, chilly, and moist. They need to be situated near a walled-off area in the basement or a garage with enough space and windows for appropriate ventilation (Elansari et al., 2019).

Figure3a.Storageofproduceinthecellar(adaptedfromKale*et al.*, 2016)

Figure 3b. A view of the cellar (adapted from Kale *etal.*,2016)

Following are some of the methods to construct storage cellars:

- Excavation of ground and building a shed or a house over the built cellar. Access can be provided from the top via a trap door
- Excavation through the hillsides is relatively easier and also permits rainwater drainage
- On rocky terrains, where it is difficult to excavate, a ground-level structure can be built. This structure, and the area surrounding it, can then be covered with rocks, earth, and sod (Kale et al., 2016).

The cellar can be used to store a wide variety of fresh produce, including beet, broccoli, potato, turnip, cabbage, carrot, pear, onion, Brussel sprouts, apple, and winter radish (El-Ramady et al., 2015; Elansari et al., 2019).

1.3.6. Ventilated storage structures: A flow of air inside ventilated storage buildings maintains the optimum storage temperature. This air may be forced into the structure or may be ventilated naturally. The simplest technique is natural ventilation storage, in which humidity is produced by product respiration and heat surrounding the product is continuously removed by natural airflow. Forced air ventilation, on the other hand, uses auxiliary fans to speed up the pace of heat and gas exchange. 10–13 m/s of air pressure is driven through the crop that has been stored.

Figure4.Storageinnaturalventilation(adaptedfromElansari*etal.*,2019)

1.3.7. Natural ventilation: Natural airflow around the produce in the case of natural ventilation (Fig. 4) removes heat from respiration and humidity from the product or other elements. Natural ventilation can be used in any building or structure that safeguards the items and has openings for adequate airflow. The arrangement of fresh food may be in bulk, bins, pallets, bags, or cartons. Natural ventilation has the significant drawback of leaving produce exposed to pathogens, pests, and unfavourable climatic conditions that might reduce the quality of the final product (Elansari et al., 2019).

Figure5.Ventilatedstorage-Nasiktype(adaptedfromKale*et al.*, 2016)

Naturally ventilated structure can be employed for the storage of fruits and vegetables, including roots, tubers, onions, pumpkins, garlic, and hard white cabbage. Some of the improved storage structures for onions include high volume - bottom and side ventilated storage structure (25-50 tons capacity), concentric structures, low volume low-cost structures (5-10 tons capacity) made of bamboo, Nasik type storage structure (Figure 5), etc. (Kale et al., 2016).

Table 1.1.Temperaturedropchart(adaptedfromKale*etal.*,2016)

Temperature(°C)	**R.H.(%)**								
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
10	4.0	4.5	5.5	6.0	7.0	7.5	8.0	9.0	9.5

15	7.5	8.5	9.5	10.5	11.0	12	13	13.5	9.5
20	11	12	13	14.5	15.5	16.5	17.5	18.5	19
25	14.5	16	17	18.5	20	21	22	23	24
30	17.5	19.5	21	22.5	24	25	26.5	28	29
35	20	23	25	26.5	28.5	30	31.5	32.5	34
40	23	26.5	29	31	32.5	34.5	NA	NA	NA
45	26	29	32.5	35	-	-	-	-	-
50	29	32.5	36.5	-	-	-	-	-	-

1.3.8. Forced air ventilation: By blowing air into the storage structures with the aid of a fan, the exchange of gases and heat can be enhanced. The storage space is used more effectively in this way. The air conducts are housed in a perforated floor, and air is pushed into the produce through them. Fan capacity, conduct dimensions, as well as loading patterns, should be carefully engineered to provide an even distribution of air throughout the stored produce. Designing must take into account that forced air chooses the route with the least amount of resistance (El-Ramady et al., 2015).

1.3.9. Evaporative cool chambers: Produce is cooled in evaporative cooling chambers using a physical phenomenon in which cooling of an object or a liquid in contact with it occurs when a liquid evaporates into the atmosphere, typically into the surrounding air (Basediya et al., 2013; Ndukwu and Manuwa, 2014). The rate of cooling is controlled by the humidity of the surrounding air, which also determines how efficient it is..

1.3.9.1. Benefits

- Distress selling of fresh produce like fruits, vegetables, and flowers can be avoided
- It is suitable in rural areas as it is easy to operate and does not require special skills
- Locally available materials can be used for construction
- Capacity can be adjusted to the household need
- Fresh horticultural produce gets better marketability than ambient
- Nutritional value is retained
- Green and non-polluting
- Energy use can be reduced up to 70% in highly efficient evaporative cooling systems
- The moisture content of surrounding air is improved by evaporation that prevents the drying out of the produce, and hence, enhancing the shelf life
- Less cost-intensive
- Easy to fabricate and maintain
- Fruits and vegetables can be stored for 3-5 days without any substantial quality deterioration.

Shortcomings

• A constant supply of water is needed to keep the pads wet. Hence the water needs are significant.

• Space is needed in the vicinity of the house.

• Inappropriate water quality can damage the cooler.

• The evaporative cooler performance can be hindered by high dew point (humidity) conditions (Basediya et al., 2013)

Some of the evaporative cooling structures are explained below:

1.3.9.2. Pot design: This evaporative cooler can be used at home and has the simplest design. Inside a sizable water-holding pot is a storage pot. The inner pot contains the item that needs to be cooled. The Janata cooler (Figure 6), created by India's food and nutrition board (Roy and Khurdiya, 1985), is one modification of this concept. This has a storage pot inside of an earthen bowl filled with water. The pot is then covered with a moist cloth before being submerged in the water reservoir. The bowl's evaporating water is absorbed by the fabric, bringing down the temperature of the storage pot. Wet sand separates the pot from the earthen basin in the ground (Kale et al., 2016).

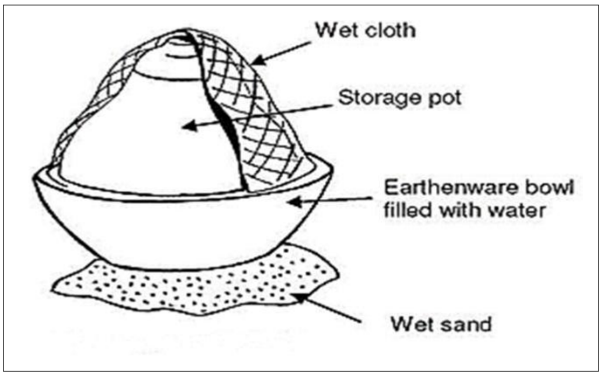

Figure 6. Pot type evaporative cooler (adapted from Roy and Khurdiya, 1985)

1.3.9.3. Charcoal cooler: It is constructed of an approximately 50mm x 25mm open timber frame (Figure 7). The frame's one side serves as a hanging door. Mesh has been used to completely enclose the timber structure, both inside and out. The mesh has a 25mm-long hole that is filled with charcoal chunks. Water is sprayed onto the charcoal to create evaporative cooling. To stop spoiling from rats and mice, this framework is mounted on a pole with a metal cone. The entire setup is situated outside the structure. Additionally, a good layer of grease is applied to stop ant-related deterioration. This system's top is typically solid and thatched, with an overhang to keep flying insects out of the stored goods. (Kale et al., 2016; Odesola and Onyebuchi, 2009).

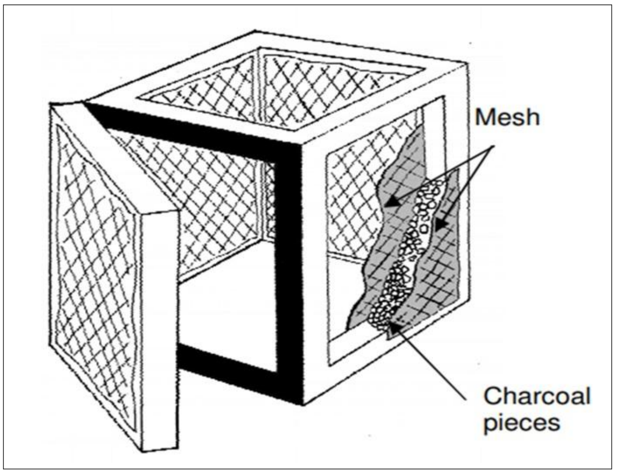

Figure 7. Charcoal cooler (adapted from Odesola and Onyebuchi, 2009).

1.3.9.4. Zero Energy Cool Chambers: These chambers are built using the direct evaporative cooling theory. They operate without the use of electricity or other forms of power. Bricks, sand and bamboo are among the readily accessible building materials (Figure 8). ZECCs (zero energy cool chambers) are double-brick-walled buildings. Sand is used to fill the cavity, and the chamber's walls are submerged under water. Unskilled labourers can readily build the chamber. By using this technique, the crop's temperature can be lowered by 10 to 15°C while maintaining a high humidity level of around 90%. Therefore, ZECC aids in maintaining the quality and lengthening the shelf life of fresh goods. By holding product for a short period of time, such methods can help small and marginal farmers circumvent middlemen or intermediates in retail chains.

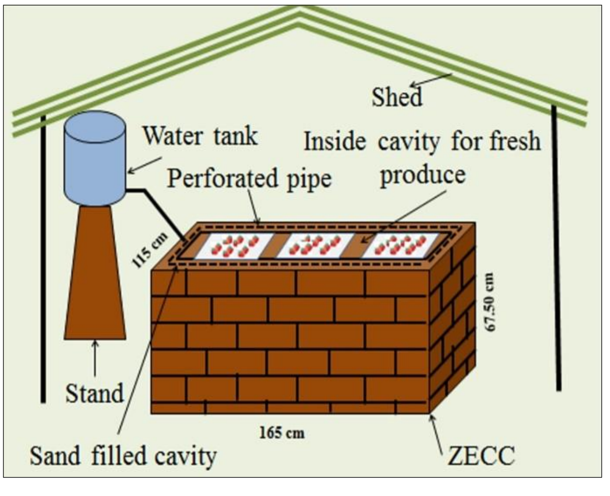

Figure 8. Zero energy cool chambers (adapted from Khalid et al., 2020).

a. Construction of ZECC

- An area is selected having a water source nearby
- Brick floor is made with dimensions of 165 cm x 115 cm.

- Double-wall is set up with a height of 67.5 cm, leaving a 7.5 cm cavity
- The chamber is imbibed with water
- Fine riverbed sand is saturated with water and filled in the 7.5 cm cavity left in the double wall
- The top cover frame is made (165 cm x 115 cm) with bamboo and straw or dry grass
- Ensure sun or rain protection with a shed over the chamber

b. Operation

- The sand, top cover and bricks of the chamber should be kept wet with water
- Connect a drip line to an overhead water source to ensure a continuous water flow and maintain the required

environment

- Fruits and vegetables must be stored in perforated plastic crates in this chamber
- Thin sheets of polythene should be used to cover these crates

c. Necessary precautions during ZECC construction

- Locate the system at a place which has abundant access to the airflow
- Avoid waterlogging by building the structure at an elevated place
- Good quality bricks with significant porosity should be used.
- No organic matter or clay should be present in the sand used.
- The sand and bricks used should be water- saturated
- Using a roof over can prevent direct solar exposure.
- Prefer crates made of plastic over wooden, fiberboard, bamboo baskets, gunny bags, etc.
- Avoid the contact of water with the fresh produce.
- Ensure cleanliness in the chamber and disinfect regularly using permitted fungicide, insecticide, or chemicals to protect against fungus, insects, rodents, pests or reptiles, etc.

1.4. Improved/ Modern storage methods/ High cost storage technologies

Several improved and novel packaging and storage technologies have been experimented and commercialized for fruits and vegetables. These include refrigerated storage, CAS, MAP and hypobaric storage. Important considerations for commercially adopting these technologies for bulk- level include cost-effectiveness, eco-friendliness, product quality and applicability range, storage area to product volume ratio, skill requirement, process control, energy requirement and safety aspects. Some improved storage technologies for horticultural crops are discussed below:

1.4.1. Cold storage: The ideal storage space temperature is directly correlated with the amount of product respiration. The rate of respiration of the produce decreases as the temperature drops, which further slows the rate of biochemical reactions and lengthens the shelf life of the product. The fundamental component of the cold chain used in the fresh produce market is a cold storage facility. From harvest to consumer use, a cold chain ensures excellent preservation. A typical cold storage facility uses a non-toxic refrigerant to keep the area cool, and to prevent heat loss, the walls are insulated with polyurethane foam (PUF). Cold storage facilities that uphold the necessary fresh produce storage conditions in addition to ventilation enable adequate storage.

Figure 9. Cold storage

a. Benefits

- Reduces respiration rate and thus perishability
- Reduces transpiration: lessens shriveling, reduces water losses
- Decreases ethylene production: slows ripening
- Enhances resistance to ethylene action
- Reduces microbial activity
- Decreases browning and maintains texture, nutrients and flavour
- Postpones ripening and reduces natural senescence.

b. Post-harvest technologies for inhibiting or delaying chilling injury

Some fruits suffer chilling injuries when they are exposed to low temperatures that are not quite freezing. the physiological changes brought on by chilling damage, which include changes to metabolism, might cause bruising to form on the surface of the fruit or cause it to ripen abnormally. When delicate horticultural produce is stored in modern storage facilities, care is being taken to prevent or delay the development of chilling injuries. When storing sensitive fruit, factors like variations in temperature, gas composition, or relative humidity are taken into account as they might affect the frequency and severity of these injuries. Industries frequently employ these techniques. Examples include high-temperature pretreatment, conditioning at moderate temperatures, using CO2 before or during storage, and intermittent warming.

1.5. CONTROLLED ATMOSPHERE STORAGE: In a CAS system, the produce is kept at reduced O2 and high CO2 concentrations with an appropriate temperature range and RH

Table 1.2.Recommendedconditionsforcontrolledatmospherestorageofsomehorticulturalcrops(adaptedfromKader,1992)

Fruitsandvegetables	Temperature(C)	%Oxygen	%Carbondioxide
Apple	0-5	2-3	1-2
Bananas	12-15	2-5	2-5
Cantaloupe	3-7	3-5	10-15
Kiwifruit	0-5	2	5
Lettuce	0-5	2-5	0
Nutsanddriedfruits	0-25	0-1	0-100
Strawberry	0-5	10	15-20

a. Benefits of CAS

- It reduces the rate of respiration and ethylene production and hence, retards senescence of fresh products
- It decreases the responsiveness of fruits towards the ethylene action
- It prevents several physiological disorders, such as russet spotting in lettuce, chilling injury in a variety of products and some storage problems, including apple scalds

The losses of some other vitamins, especially those susceptible to oxidation, can be prevented. Several commodities' shelf life can be extended up to 2- 4 times the usual shelf life. The composition of CO2 and O2 levels in controlled atmosphere storage is kept within maintained and controlled levels in gas-tight containers or stores. The leakages in the walls and door of the storage area and the ripening produce's metabolic activities prompt a continuous change in the gas composition of the storage space. The gas composition is thus monitored periodically, and fresh air or nitrogen is input to maintain a predetermined level of headspace gas composition. It can also be done by passing the atmosphere of the store through a chemical for removing carbon dioxide. A system can be designed which initially flushes gases to lower the oxygen content and after that either injects carbon dioxide or allows it to cumulate through produce respiration. This atmosphere can then be maintained by scrubbing and ventilation. Table1.2 describes the recommended conditions for some fruits and vegetables for which CAS is commercially used.

- It has fungistatic effects and can prevent the incidence of various fungi and bacteria
- Insect attacks can be controlled
- It maintains the quantitative and qualitative aspects of the product for an extended period and hence helps

improve their shelf life

b. Potential negative effects

- Very low volume of oxygen and/or a very high volume of carbon dioxide (depending upon the duration of treatment, type of food and temperature) can change aerobic into anaerobic respiration which can lead to fermentation
- Some physiological disorders may be initiated or aggravated, for example, brown coloured stains on lettuce, blackheart in potatoes and brown heart in pears and apples
- Fruits such as mango, banana, tomato and pear can experience irregular ripening due to stress from an oxygen content below 2% or carbon dioxide content above 5%, for more than 2 to 4 weeks
- Anaerobic respiration and fermentation due to low oxygen and high carbon dioxide volume can lead to the development of off-odours and off-flavours
- Fungi and other micro-organisms can penetrate in inadequate gas levels through plant tissues. Furthermore, at low levels of oxygen and/or very high levels of carbon dioxide, bacterial development, which is a potential risk in fresh produce (especially minimally processed horticultural products) can be facilitated

1.6. MODIFIED ATMOSPHERE PACKAGING:

In order to improve the keeping quality, shelf life, and reduce the metabolic activity rate of the product stored, MAP comprises the storing of fresh produce in environments whose gas composition has been altered in comparison to that of air (Coles et al., 2003). A MAP's various processes are depicted in Figure 10. Fresh horticultural produce's MAP calls for replacing the reactive gases in the package headspace with non-reactive gases that have a different composition from air. The package atmosphere is replaced in the headspace by a mixture of CO2, O2, and N2. The nature of fresh produce determines the composition and amount of gases being used. Some of the key factors affecting the effectiveness of MAP are the rate of respiration of the produce, oxygen and carbon dioxide permeability of package material, storage temperature and headspace volume of gases present inside the package (Soltani et al., 2015). MAP can be passively or actively modified.

1.6.1. Passive MAP: Rate of respiration of the produce and permeability of the packaging material play a crucial role in passive MAP. The oxygen use is proportional to the package atmosphere's carbon dioxide production due to the product respiration.

Eventually, the headspace gas composition reaches an equilibrium between the product respiration rate and package material permeability. During the equilibrium state, the total volume of CO2 production and O2 utilization become equivalent to gases permeated through the membrane surface.

1.6.2. Active MAP: In actively modified MAP, the package atmosphere is evacuated and then replaced with the desired composition of gases. This is done to ameliorate the modification of the in-package gas composition and further prevent stress-induced exposure to high gas concentrations (Zhang et al., 2015).

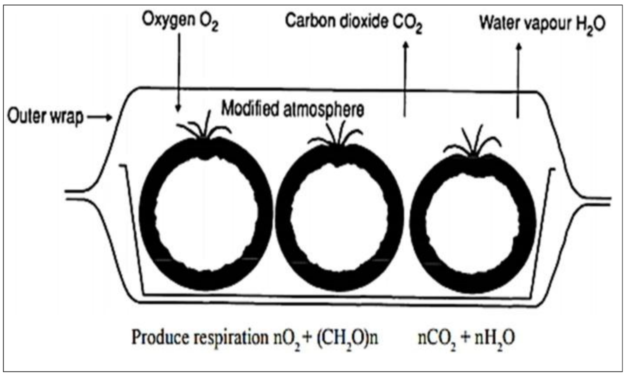

Figure 10. Processes in a modified atmosphere pack (adapted from Paine and Paine, 1992)

1.6.3. Polymeric film applications for MAP of horticultural crops

Flexible package structures have seen the most significant application of polymeric films for MAP (Mangaraj et al., 2009). Certain variables viz. oxygen and carbon dioxide permeability through film, film thickness, water vapour transmission rate (WVTR), the free volume within the package and the package surface area decide the degree of modification of the gases within the package (Ares et al., 2007; Beaudry, 1999; Cameron et al., 1994; Mahajan et al., 2008). These factors are key to determining the composition of in-package environment and humidity and hence can influence the product's deterioration rate. Several films have been used for MAP, the most commonly used being Low-Density Polyethylene, High-Density Polyethylene, Polypropylene, Polyvinyl Chloride, Polystyrene and Polyesters. Table 3 gives permeability of O2 and CO2 (determined at 25˚C) and water vapour transmission rate (determined at 38˚C) of some commonly used films in MAP

Table 1.3. Permeabilities and water transmission rates of films commonly used for modified atmosphere packaging (25µm film).

Film	**Permeability,cm^3/m^{2}datm(at25^{o}C)**		**Watertransmission,g/m^{2}d(at38^{o}Cand90%RH)**
	O_2	**CO_2**	
Low-densityPolyethylene	3900-13000	7700-77000	6-23
Medium-densityPolyethylene	2600-8300	7700-38750	8-15
High-densityPolyethylene	520-4000	3900-10000	4-10
Polypropylene	1300-6400	7700-21000	4-11
PolyvinylChloride	150-2200	450-8000	30-40
Polystyrene	2000-7700	10000-26000	100-150
Polyurethane	800-1500	7000-25000	400-600
Polyamide	40	150-190	84-3100

1.7. Hypobaric Storage / Low-Pressure Storage:

A pressure lower than 101 kPa is referred to as hypobaric pressure or sub-atmospheric pressure. A low-oxygen environment is established at sub-atmospheric pressure ranges in hypobaric storage, a sort of controlled atmospheric storage that is relatively less well understood. This lengthens the storage life of goods by lowering their respiration rates and metabolism kinetics. Reduction in total pressure is proportional to the decrease in the oxygen partial pressure (John, 2008). The product is stored under a partial vacuum in a chamber. The chamber is vented continuously with saturated air to maintain the low-oxygen partial pressure ranges. Generally, a 10kPa decrease in the air pressure (equal to an oxygen partial pressure of 2.1 kPa) permits a 2% reduction in oxygen concentration at normal atmospheric pressure (Vithu and Moses, 2017).

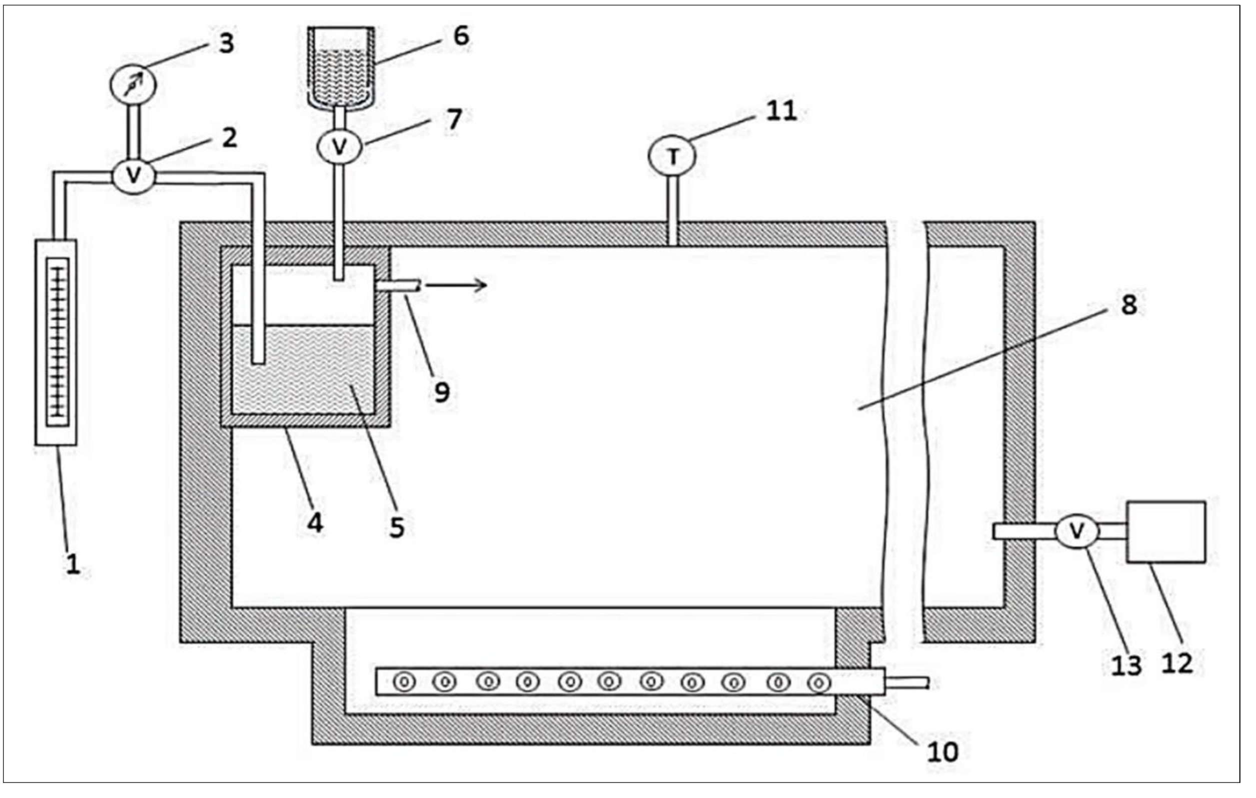

Figure 11. Hypobaric storage unit: (1) Airflow chamber, (2) needle valve, (3) vacuum gauge, (4) humidifier,

(5) distilled water, (6) water reservoir, (7) valve, (8) storage chamber, (9) conduit, (10) refrigeration unit, (11) temperature gauge, (12) vacuum pump, (13) throttle valve.

1.7.1. Working principle of a hypobaric storage system

A typical hypobaric system consists of a product storage chamber, a vacuum pump, a refrigeration unit and a humidifier (Figure 11). Air enters the system through the airflow chamber (1). A needle valve (2) is used to regulate the incoming low- pressure air (whose downstream pressure is measured using a vacuum gauge (3). Air is allowed to enter a humidifier (4) to increase the R.H. to about 80–100% (as in most cases). For this purpose, distilled water (5) from a water reservoir(6) is added periodically to the humidifier, with the help of a valve (7). The humidification system removes respiratory heat and any other additional heat received from the environment; thereby preventing water loss. Saturated air is supplied to the vacuum storage chamber (8) through a conduit (9). Food commodities are stored in this chamber under vacuum (usually 4–400 mm Hg absolute). Storage temperature is an important parameter and is kept under control (–2 to 15°C) using a refrigeration unit (10) designed in the form of coolant tubes. A temperature gauge (11) shows the variation in temperature during storage. To ensure the low pressure in the storage chamber, a vacuum pump (12) is provided. A pressure regulator/throttle valve (13) controls the entry/exit of air from/ to the system.

1.8. CONCLUSION

Farmers and the food industry face a serious problem with post-harvest losses of horticulture crops because of their short shelf lives and inappropriate storage. To minimise these losses and preserve the crop's quality until market demand, several storage structures are designed based on temperature and environmental management. Farmers can increase their income by using traditional storage facilities like clamps, pits, cellars, and evaporative cooling chambers. However, they are incapable of long-term storage of a large quantity of goods. Evaporative cooling systems are developing new technologies. When it comes to producing more output with fewer resources, structures like pot-in-pot designs and zero energy evaporative cooling structures are advantageous.

Improved and contemporary methods, such as cold storage, CAS, MAP, and hypobaric storage, are now also in use. Although expensive, these methods have been successful in extending the shelf life of many horticultural crops by providing the proper storage conditions. There is a huge range when it comes to the storage of horticulture crops, and various storage systems are being researched for various crop species.

EXERCISE

1. **Define major crops grown in the country.**
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2. **Explain the characteristics of rice production**

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3. **Explain the ideal climatic condition of wheat and jowar**
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4. **Define climacteric condition for production of coffee plants.**

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5. **Traditional storage structures can be beneficial for farmers needing a small-scale storage system**

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6. **Traditional storage technologies/low-cost storage technologies**

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7. Define Pot design

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8. Explain Charcoal cooler

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9. Explain Zero energy cool chambers

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10. Write down the Construction of ZECC

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KEY WORDS:

Cereals: Cereals are the major crop of india comprised of grains and millets.

Pits: Pits are trenches where a cavity has been excavated.

Clamps: Clamps are used to store potatoes

ZECC: Zero Energy Cool Chambers:

Cold Storage: The ideal storage space temperature is directly correlated with the amount of product respiration.

CAS: Controlled Atmosphere Storage:

MAP: Modified Atmosphere Packaging

Hypobaric Storage / Low-Pressure Storage: A pressure lower than 101 kPa is referred to as hypobaric pressure or sub-atmospheric pressure.

UNIT II - PHYSICAL PRINCIPLES IN FOOD PROCESSING OPERATIONS:

STRUCTURE:

OBJECTIVES :

2.0. INTRODUCTION
2.1. FOOD PROCESSING

OBJECTIVES :

Objectives After studying this unit, you will be able to:

I. Discuss the concepts and aims of food processing
II. Describe the principal of food processing and preservation
III. Describe the thermal processing methods of food preservation and
IV. Describe the dehydration and water activity in food products
V. Describe the process of refrigeration and freezing
VI. Describe ionizing radiation

2.0. INTRODUCTION

We learned about the fundamentals and conventional approaches to food storage in the previous unit. Now, we'll discover a thorough review of the various food processing techniques employed today in this unit. The most popular food processing techniques used at home or in business include thermal processing, dehydration, freezing, and irradiation. What is involved in the procedure? What further thermal processing techniques are there? These topics are covered first in this section, and then a descriptive essay on dehydration, one of the conventional approaches to food processing, follows. This unit covers the food processing techniques of freezing and irradiation.

2.1. FOOD PROCESSING

As you already know, food processing entails transforming components and raw materials into a consumer-acceptable food product. It includes all steps required to get raw materials from the "harvest site" to packaging and selling. It involves using scientific principles to slow down or stop food deterioration caused by microorganisms, food-derived enzymes, or environmental variables including heat, moisture, and sunshine in order to preserve the food. A lot of this knowledge is conventionally understood and used through experience and knowledge that has been passed down through the years. Food scientists work to increase the efficiency of food production, processing, and storage processes through a scientific understanding of the underlying systems. Processing is a fairly broad concept, and Processing is a very general phrase that refers to a variety of methods.

These include preliminary operations like cleaning, washing, sorting, grading, peeling, blanching, and cutting in the case of fruits and vegetables, as well as primary processing steps like threshing, dehusking, polishing, and grinding in the case of food grains. Other steps are used to create secondary processed products like breads, biscuits, confectionery, dehydrated and canned products like jams, jellies, pickles, sauces, frozen meals, etc. The bulk of foods are treated in some form before consumption due to the wide variety of procedures.

2.2. AIMS OF FOOD PROCESSING

Food processing may be done for a variety of reasons, but the major goals are to:

• keep food from spoiling due to bacteria and other spoilage causes, preserving its nutritious qualities;

• extend shelf life (for example, through preservation). This is due to the fact that processed food tends to be more stable than raw food.

• raise the bar (for example, in cookery);

• guarantee food safety for eating in the future,

• guarantee the year-round availability of a variety of food products.

• simplicity of distribution, transportation, and storage systems;

• to produce additional cash and employment.

2.3. METHODS AND PRINCIPLES OF FOOD PRESERVATION

One of the first technologies employed by humans is food preservation. If special preservation techniques are not utilised, a significant amount of perishable food products, such as fruits, vegetables, milk, meat, fish, and others, would deteriorate or decompose quickly and will be wasted at various points along the food supply chain. Food preservation is the process of giving perishable food materials a suitable physical or chemical treatment to minimise loss, deterioration, and to maintain their nutritional value for extended periods of time. The processing methods used to keep food from spoiling are referred to as food preservation principles.

The many preservation methods used most frequently today are listed in the

2.3.1.METHODS OF FOOD PRESERVATION.

1. Asepsis, or preventing microbes

2. Microorganism removal (filtering, centrifuging, washing, and trimming)

3. Upkeep of anaerobic conditions, such as in an evacuated, sealed container

4. Drying (smoking, mechanical drying, freeze drying, and drying in the sun)

5. The use of high-salt or high-sugar preparation methods (sugaring, pickling, curing, etc.)

6. Utilizing acids

7. Fermentation

8. Using low temperatures (freezing, chilling, and refrigeration)

9. Using high temperatures (for canning, boiling, and pasteurisation)

10. Mechanically eliminating microorganisms, such as via high pressure, grinding, etc.

11. Preservatives made of chemicals

12. Carbonation

13. Irradiation,

14. Combining two or more of the aforementioned techniques.

All of the food preservation techniques listed in above Table are founded on the general idea of preventing or delaying the causes of spoilage caused by microbial decomposition, enzymatic and non-enzymatic reactions, chemical or oxidative reactions, and damage from mechanical causes, insects and rodents, among other things. The fundamental tenets of the various preservation techniques are described in

2.3.2. PRINCIPLES OF FOOD PRESERVATION

1. Stopping or postponing microbial degradation

   a. By preventing the presence of bacteria (asepsis)

   b. By eliminating microbes, such as via filtration.

   c. By preventing the development and activity of microbes, such as by using chemicals, low temperatures,

   drying, or anaerobic conditions.

   d. By using heat or radiation to eliminate the bacteria.

2. Stopping or delaying the food's self-decomposition:

   a. By inactivating or destroying food enzymes, such as by blanching.

   b. By delaying or stopping chemical reactions, such as by using an antioxidant to stop oxidation.

3. Damage avoidance due to mechanical, animal, and insect causes.

2.4. : THERMAL PROCESSING

The term "thermal processing" refers to the carefully regulated application of heat to alter the speeds of reactions in food that may be chemical, enzymatic, microbiological, or any combination of these.

2.4.1. Effect of thermal processing on microbiological activity-

The main goals of thermal procedures are to limit the growth of harmful and spoilage microorganisms and to eradicate or reduce the quantity of germs that are significant for public health to an acceptable level (commercial sterility). While sterilization procedures aim to provide shelf-stable products with a lengthy storage life, pasteurization treatments depend on storing processed foods under refrigeration for a set maximum amount of time. From the perspective of public health, the main standard for sterilizing low acid foods (pH>4.5) is the destruction of C. botulinum, while for acid foods, additional bacteria of the spoilage type are used.

2.4.2. Effect of thermal processing enzyme activity

If not inactivated, certain enzymes (peroxidase, lipoxygenase, and pectin esterase) can result in unfavourable quality changes in foods while being stored, even in a refrigerator. It is common practice to use the inactivation of heat-resistant enzymes (pectin esterase, phosphatase, and peroxidase) as the foundation for the thermal processing of acidic foods and the pasteurization of dairy products. The majority of enzymes are inactivated in traditional thermal processes either because they are used as indicators in the processes or because they are less heat-resistant than other indicator bacteria. When compared to microorganisms, some of these oxidative enzymes have been found to have an extremely low temperature sensitivity.

2.4.3. Effect of thermal processing on food quality

The application of food processing techniques that extend the availability of perishable foods also limits the availability of some of the essential nutrients. Maximizing nutrient retention during thermal processing has been a considerable challenge for the food industry in recent years. The major concern from a food processing point of view is the inevitable loss of heat-labile nutritional elements that are destroyed, to some degree by heat. The extent of these losses depends on the nature of the thermal process (blanching, pasteurization, sterilization). The major emphasis in food processing operations is to reduce these inevitable losses through the adoption of the proper time temperature processing conditions, as well as appropriate environmental factors (concentration, pH, etc.) in relation to the specific food product and its target essential nutrient.

2.5. BLANCHING

Blanching perhaps represents the least severe heat of the above processes; however, nutrient loss during blanching can occur due to reasons other than heat, such as leaching. Steam and hot water blanching are the two most commonly used blanching techniques. These conventional processes are simple and inexpensive but are also energy intensive, resulting in considerable leaching of soluble components (which occur both during heating and cooling), and produce large quantities of effluent. With steam blanching, it is possible to significantly reduce the effluent volume, as well as leaching losses. The individual quick blanching (IQB) technique is an innovation based on a two-stage heat-hold principle and has been shown to significantly improve nutrient retention. The vegetables are heated in single layers to a temperature high enough to inactivate the enzymes, and in the second stage they are held in a deep bed long enough to cause enzyme inactivation.

The loss due to blanching can be up to 40% for minerals and vitamins (particularly vitamin C and thiamin), 35% for sugars, and 20% for proteins and amino acids, depending on the method of blanching, commodity, and component involved. As a result of the heat breakdown of blue/green chlorophyll pigments to yellow/green pheophytins during blanching, various unwanted colour changes may occur. Chlorophylls react negatively to metal ions and pH changes. Chelating compounds and an alkaline pH prefer better green colour retention. Low-temperature blanching has been demonstrated to enhance the texture of several goods (carrots, beans, potatoes, tomatoes, and cauliflower), whereas other heat treatments degrade texture. This is because the pectin methyl esterase enzyme is activated during low-temperature blanching.

2.6. PASTEURIZATION

Pasteurization is a heat treatment used on food that is less extreme than sterilization yet effective enough to inactivate certain disease-producing organisms in a given food. Most viable vegetative bacteria are rendered inert by pasteurisation, however heat-resistant spores are not. Pasteurization was initially used to destroy bovine TB in milk. Ratios on the order of 1015:1 result in a decrease in the number of viable organisms.

Pasteurization may be taken into account in regard to dietary enzymes that are present and can be rendered inactive by heat, in addition to the application to inactivate bacteria. For pasteurization, the same fundamental linkages that were covered for sterilization apply. It is necessary to use a temperature and time combination that will effectively inactivate the specific bacterial or enzyme species in question. Fortunately, the majority of pathogenic organisms that can be spread from food to a person who eats it are not particularly heat-resistant. The process is most frequently used to pasteurize liquid milk.We have learnt that the nutritional and sensory characteristics of most foods are only slightly affected by the pasteurization process because of its mild heat treatment. However, because it is only a temporary method of shelf-life extension, the product quality continues to change (deteriorate) during storage.

The post-pasteurization packing conditions and storage environment affect the shelf life. Milk is the most significant non-acid liquid food, and as a result, it has drawn a lot of attention. As a result, there are typically no vitamin losses while pasteurizing milk for the fat-soluble vitamins A, D, E, and K. Less than 10% of the vitamins thiamin, vitamin B6, vitamin B12, and folic acid are lost as a result of pasteurisation. Up to 25% of vitamin C can be lost. Pasteurization doesn't significantly change the colour of milk. The homogenization process is primarily responsible for the colour changes between raw and pasteurised milks. Small losses of volatile fragrance molecules happen when pasteurisation is done using a low heat.

Fruit and vegetable colour changes are primarily brought on by oxygen and the action of the enzyme polyphenoloxidase. To reduce fruit and vegetable colour deterioration, deaeration prior to pasteurisation removes oxygen and heat treatment inactivates the enzyme.

2.7. STERILIZATION

As was already mentioned, sterilisation procedures go farther than the standard heat treatment used to achieve commercial sterility. There will undoubtedly be nutritional loss in these items. Vitamins A, B1, B6, B12, C, D, and E, folic acid, inositol, pantothenic acid, and amino acids like lysine and threonine are among the nutrients that are more susceptible to being destroyed by heat. The impact of the process cannot be easily evaluated due to the potential of combining a wide variety (infinite) of time-temperature combinations to achieve thermal sterilisation.

Protein, fats, and high concentrations of sucrose increase the heat resistance of microorganisms; the pH of the food; the composition of the food; the heating behaviour of the food (conduction, convection); the nature, size, and shape of the container; as well as the nature and mode of application of the heating medium. These factors all affect how severe of a heat treatment is necessary to ensure the destruction of C. botulinum. Additional variables for process optimisation are provided by agitation during processing.

Studies on the microbes found in food have led to the choice of particular bacterial species as indicator organisms. Of the bacteria that are likely to cause problems in foods, these are the most challenging to eradicate in their spore forms.

2.8. CANNING (TEMPERATURE ABOVE 100° C)

Foods are cooked in hermetically sealed (airtight) jars or cans during the canning process to a temperature that kills microorganisms and inactivates enzymes that could be harmful to human health or cause the food to deteriorate. No microorganisms can enter the product thanks to the vacuum seal that is created after heating and cooling. Depending on the type of food and the sorts of microorganisms that are likely to be present in it, different temperatures and heating times are used. Low-acid vegetables and meats must be processed in a pressure canner at 121 °C (15 psi pressure), whereas high-acid foods like fruits and tomatoes can be processed or "canned" in boiling water. The majority of canning is done in 'tin cans', which are constructed of tin-coated steel or in glass containers, although more and more containers made of aluminium, plastics such pouches, or solid containers are now being used. All types of tinned foods, including soup, meat, beans, cereal grains, legumes, nuts, and other different dried food products, including fruit, coffee, milk, soups, fish, meat, and vegetables, are examples of food preserved through canning.

2.9. THERMAL DEATH TIME

It has been discovered that heat kills bacteria, including C. botulinum, at rates that depend on temperature, with spores being killed by heat more quickly. The spores are killed at varied rates depending on temperature, with some spores appearing to be more heat-resistant than others. It is discovered empirically that the number of surviving spores decline asymptotically to zero if a graph of the number of surviving spores against time of holding at any selected temperature is drawn. Phosphatase, an enzyme found in milk, can be easily detected chemically and is used as a sign of insufficient heat treatment since it is destroyed under conditions that are similar to those of M. tuberculosis.

Regarding the storage qualities or fitness for human eating in this scenario, phosphatase's presence or absence has no bearing.
The applications of heat transfer as a unit operation in food processing are extremely well shown by the pasteurisation and sterilisation processes. Equations created for heat-transfer processes are used to construct the heat transfer equipment after determining the temperatures and times necessary.

2.10. FOOD DRYING/ DEHYDRATION

One of the first ways to preserve food is by drying or dehydrating it. Long before any historical records exist, primitive tribes used the sun to dry meat and fish. Food drying is still a crucial method of food preservation today. Foods that have been dried out can be kept for a very long time without going bad. The main causes of this are that many of the enzymes that promote undesirable changes in the chemical makeup of the food cannot function without water, and the bacteria that cause food deterioration and decay are unable to develop and reproduce in the absence of enough water.

Dried goods have a longer shelf life because of the low water content they achieve during drying, which eliminates the need for refrigerated storage or transit. Additionally, surplus that is on hand can be changed into stable forms. For instance, milk in liquid form is easily spoilable, however milk in powder form is more stable and convenient to store and manage. Egg and juice powders are further examples of dehydrated goods in this category. Typically, drying results in a large reduction in weight and bulk volume, which can lower the cost of transportation and storage. Many contemporary dehydrated products are suitable as convenience foods due to their quick reconstitution qualities and generally good organoleptic attributes.

A modern store will have a large selection of dry goods if you take a quick glance around. Examples of these foods for use in home cooking include instant coffee, tea, milk, chocolate, drinks, soup mixes and instant meals containing dried vegetables, rice, pasta, dried vegetables (such as potato flakes or granules), peas, beans, and carrots, dried meat and fish ingredients, dried fruits for use as snacks or in desserts or baked goods, and many more. It is apparent that food dehydration accounts for a sizable and highly substantial portion of manufacturing or food processing activities globally in order to offer such a broad range of products.

2.10.1. DRYING PROCESSES FALL INTO THREE CATEGORIES:

a. **Air and contact drying under atmospheric pressure.** In air and contact drying, heat is transferred through the foodstuff either from heated air or from heated surfaces. The water vapour is removed with the air.
b. **Vacuum drying**. In vacuum drying, advantage is taken of the fact that evaporation of water occurs more readily at lower pressures than at higher ones. Heat transfer in vacuum drying is generally by conduction, sometimes by radiation.
c. **Freeze drying.** In freeze drying, the water vapour is sublimed off frozen food. The food structure is better maintained under these conditions. Suitable temperatures and pressures must be established in the dryer to ensure that sublimation occurs.

2.10.2. HEAT REQUIREMENTS FOR VAPORIZATION

This temperature determines how much energy is required to vaporise water at any given temperature. The latent heat of vaporisation, if it originates from a liquid, or latent heat of sublimation, if it originates from a solid, is the amount of energy needed per kg of water. Since steam and water vapour are the same thing, the latent heats given in the steam table, which is available in any standard thermal processing text book, can be used to calculate the amount of heat energy needed to vaporise water under any particular set of conditions.

2.10.3. HEAT TRANSFER IN DRYING

The amount of heat energy needed for the drying process has been a topic of discussion. Although in some cases the rate of mass transfer (removal of the water) can be limiting, the rates of drying are often dictated by the rates at which heat energy can be transmitted to the water or to the ice in order to produce the latent heats. Conduction, radiation, and convection are the three ways heat is transmitted and can all play a role in drying. From one drying process to another, the relative importance of the mechanisms varies, and very frequently one method of heat transfer dominates to the point where it controls the entire procedure.

It should be kept in mind that the surface temperature of the meal may be higher than the ambient temperature in situations when significant amounts of heat are conveyed by radiation. The formulas created for radiant heat transfer can be used to estimate surface temperatures, but the combined effects of radiation and evaporative cooling have complex effects in reality. The conventional formulae can also be used to calculate convection coefficients.

Energy must be supplied to the surface where sublimation takes place for freeze drying to take place. It must, however, be given at a rate that prevents the temperature at the drying surface from rising past the freezing point. The primary method of heat transfer in many freeze drying applications is conduction.The nature of the heat transmission issue alters as drying progresses. Heat is gradually transported to the drying zone more slowly as dry material starts to fill the surface layers and conduction must occur through these dry surface layers, which are poor heat conductors.

2.10.4. DRYING AND WATER ACTIVITY

There are two main ways that dehydration achieves preservation. First, it eliminates the water required for enzymatic action and the growth of bacteria. Second, by eliminating the water, it raises the osmotic pressure and concentrates salts, sugars, and acids, resulting in a chemical environment that is unfavourable to the development of many bacteria. The halting of crucial processes necessary for microbial growth or spore germination results in the microbiological stability of dehydrated foods. There are a plethora of different kinds and numbers of microbes that might be connected to food. Additionally, they vary based on the meal type. and could change over the course of a food's life. Both the raw material and contamination (by people, animals, insects, water, air, contact surfaces, etc.) are potential sources of these.Fresh fruits, vegetables, meats, and milk all have water activities that lie between 0.97 and 0.99. The majority of dried foods have a maximum water activity of 0.70, which is below the threshold at which bacteria in food can exist. Only Staphylococcus aureus has the ability to grow at 0.85 aw. Unless bacterial growth is restricted, fungi (yeasts and moulds) generally grow more slowly than bacteria, but they are also more resistant to harsh environmental conditions and can degrade food in certain circumstances. Mycotoxins, which some moulds can create, can cause a range of acute and chronic toxicities in both humans and animals. Mycotoxins can occur in a variety of foods, such as cereals, nuts, figs, cocoa, coffee, etc. Even with reduced water activity, not all bacteria can be eliminated. The food's higher temperature during air drying may have an impact on living bacteria, however spores of Bacillus or Clostridium species are largely unaffected. Additionally, food toxins (from C. botulinum, S. aureus, or B. cereus) that are present as contaminants before or during drying may not always be destroyed by drying. There is no evidence that viruses, protozoa, algae, or prions can grow on food. Only their pathogenicity or toxigenicity as well as their resistance to thermal drying are thus typically taken into account. The majority of vegetative bacteria are less susceptible than these microorganisms.

Numerous other elements, such as temperature, pH, minerals, preservatives, other food ingredients, and oxygen levels, will also affect the microbial growth in addition to water activity. It's vital to keep in mind that different water activity ratings are conceivable for foods with the same water content. The food's shelf life will be greatly impacted by this.Only when a dehydrated product is shielded from additional exposure to the environment (such as water, air, sunshine, and pollutants) does it remain stable. Consequently, choosing the right packaging for a dried product is crucial.

2.11. REFRIGERATION/ COLD PRESERVATION:

A biological tissue's metabolism is influenced by the ambient temperature. Low temperatures are used to slow down chemical reactions, the activity of food enzymes, and the growth and activity of the food's microbes. The foregoing natural activities will proceed more slowly as the temperature drops. The oldest preservation techniques are freezing and refrigeration.

Commercial refrigerated warehousing and freezing were made possible by the invention of mechanical ammonia refrigeration systems in 1875. Low temperatures can be used in:

(a). Cellar storage temperatures (about 15° C): It is usually used for the storage of surplus foods like root crops, potatoes, onions, apples, etc. for limited periods.

(b) Refrigerator or Chilling temperatures (0 to 5 degrees Celsius): When food is maintained at this temperature, microbial activity and chemical alterations that lead to rotting are slowed down. For this, a mechanical refrigerator or cold storage is employed. Examples of this include foods that can be maintained by refrigeration for 2–7 days including meats, poultry, eggs, fish, fresh milk and milk products, fruits, and vegetables.

(c) Freezing (-18°C to - 40°C): Food water freezes into ice, making it impossible for processes to take place or for microbes to proliferate. At this temperature, the majority of perishable items, including poultry, meats, seafood, ice cream, peas, vegetables, juice concentrates, etc., can be preserved for a number of months. When freezing veggies, enzyme action may still have an unfavourable impact on flavour and texture. Thus, before freezing the vegetables, heating, like blanching, must render the enzymes inactive.

2.12.PROCESS OF FREEZING

In the event of freezing, the product is cooling, and in the case of thawing, the product is warming. The temperature of the product will initially drop from its original level (often at a temperature above its freezing point) until it reaches its initial freezing point during freezing. As the latent heat is then released, the product's temperature remains comparatively stable. Instead of remaining constant, the temperature for food goods gradually decreases until the majority of the water has turned into ice, at which point it falls more quickly, On the other hand, the substance is originally frozen in the case of thawing. Heat is applied so that a product that is entirely frozen at a temperature well below its freezing point heats up. Ice along the surface first warms up until it reaches the freezing point, just like during the freezing process. After that, the latent heat is introduced, and the ice starts to melt.

As a result, heat is lost from water during the freezing process, and added back to ice during the thawing process. Ice has a significantly higher thermal conductivity and thermal diffusivity than water. Which process—freezing or thawing—will last longer under similar circumstances? thawing, when the product ice melts into water, or freezing, when the food water is frozen to ice? What is freezing? No! The process of thawing takes more time. Why? See the justification below.

Because of this, heat is transferred from water during freezing and added back to ice during thawing. Thermal diffusivity and thermal conductivity of ice are substantially higher than those of water. Under equal conditions, which process—freezing or thawing—will persist longer? freezing when food water becomes to ice instead of thawing when the product ice melts into water. What is freezing? No! The process of defrosting things takes longer. Why? The explanation is given below.

when the water in the food has turned to ice? Freezing is what? No! It takes longer for things to defrost. Why? The justification is provided below.The inner, frozen layers are taken off. As a result, during the freezing process, heat is mostly transferred through a growing ice layer. The surface of frozen material melts during thawing as heat is applied to the ice, forming a layer of water. More ice melts as heat is added, expanding the water layer as a result. The expanding water layer must conduct additional heat to the inner ice layers. Consequently, the input of heat through an expanding layer of water drives the thawing process. Consequently, heat transfer during the thawing process is through a layer of water that is increasing in size. Thus, in the thawing process, the heat transfer is a layer of water that is expanding through it. Thus, heat is transferred throughout the thawing process through an expanding layer of water.

The different methods of freezing are generally grouped as :

2.12.1. Air freezing

2.12.2. Plate freezing

2.12.3. Liquid immersion freezing

2.12.4. Cryogenic freezing

2.12.1. Air freezing

One of the most used commercial freezing techniques is air freezing. The substance, whether it is packed or not, freezes when exposed to air at -18 to -40 OC. Freezing in a space with extremely sluggish air circulation is referred to as "slow" or "sharp" freezing. The term "sharp" seems to be misleading; "still air freezing" would be a better description. It is also uncommon. The delayed freezing and tendency to form huge ice crystals that degrade the product quality make this procedure clearly undesirable. The product's sluggish cooling could also encourage some undesired enzyme and microbial activity before the freezing process is finished, lowering the quality of the final product once again. When a product is frozen using air blast freezing, it is subjected to a strong blast of cold air that circulates while being driven to reach temperatures between -18 and -40 OC. There are numerous systems available, including fluidized beds, cabinets, tunnels, and belts. Trays or a single conveyor might be used to place the product. It is frequently referred to as a "tunnel" freezer when the latter is used. In this instance, the product is typically transported through an insulated tunnel where cold air is compelled to move quickly. A countercurrent flow is typically used. The conveyor length is created in a way that a variety of products are frozen as they come out of the tunnel by properly changing the conveyor speed. Another variation of air blast freezing is fluidized bed freezing. A strong blast of cold air is used here to fluidize items that are in the form of peas, kernel corn, chopped beans, brussels sprouts, strawberries, cherries, etc. The product is typically laid out in a layer that is 1 to 10 cm thick on a perforated mesh or belt. The cold air is then passed over the product from below at a pressure and speed that causes the product to literally float in the air current. The medium is thoroughly touched and stirred, which causes the freezing to happen quickly.Fish fillets and other non-fluidizable items are occasionally processed in a similar manner. Essentially, this is comparable to tunnel freezing, except instead of the tunnel's countercurrent mechanism, the cold air is moving from bottom to top. Because the air moves through the product, this sort of freezing is known as "through flow" freezing.

2.12.2. Plate freezing

In this kind of freezer, the food, which is typically packaged in standard-sized packets, is frozen by coming into contact with a metal plate that is being circulated with either cold brine or refrigerant to keep it chilly. The packaged goods are typically sandwiched between double contact plates using a light pneumatic pressure to provide a good seal between the package and the contact surface. Heat is transferred from the package's two sides. By reducing moisture loss from the product during freezing, this approach has several advantages over air-freezing.

2.12.3. Liquid-immersion freezing

The product, whether packaged or not, is submerged in the chilling medium using this approach, as the name suggests. Because heat transmission through direct contact liquid media is substantially more effective than from air, the process is rather quick. The freezing of orange juice concentrates is one application where aqueous solutions of propylene glycol, glycerol, sodium chloride, calcium chloride, and sugars have been tested.

2.12.4. Cryogenic freezing

Due to the extremely low temperatures of the cooling medium, cryogenic freezing allows for a very quick freezing. Common cryogenic freezing agents include liquid or solid carbon dioxide and liquid nitrogen. Solid CO2 sublimes at -79OC while liquid nitrogen boils at -196OC. The conversion of CO2 from a solid to a gas through sublimation can absorb around three times as much latent heat as liquid N2 (246 to 86Btu/lb). In this process, a tunnel is typically used to transport the product through the freezing chamber. The emerging nitrogen gas vapours will meet the product as it enters at a temperature of between 30 and -40 OC, pre-cooling it. The item is frozen in the tunnel's central freezing chamber. after a quick exposure to a liquid N2 spray. The contact time is determined by the conveyor speed. The product will then flow out with the N2 vapours after that, where it will equilibrate to the preferred finishing temperatures. When using CO2, the product is tumbled with powdered CO2, which may not be ideal for sensitive products.In a freezer, liquid CO2 behaves somewhat differently than liquid nitrogen. High-pressure liquid CO2 is fed into the tunnel at 300 psi, but as soon as it reaches the injection orifice, it instantly expands into a mixture of gas and minute dry ice solid particles (15-109OF). The heat from the food product quickly causes the dry ice to "sublimate," or phase directly from a solid into a gas. The dry ice solid, often known as dry ice "snow," is blasted into the surface of the food product.

2.13. IONIZING RADIATION:

Ionizing Radiation Types The electromagnetic spectrum contains waves that are invisible to the human eye, such as gamma rays, X-rays, and electron beams (U.V. rays also fall into this category but have a longer wavelength than X-rays or gamma rays). Ionising radiations are high-energy radiations that have the ability to convert atoms into electrically charged ions by removing an electron from their outer orbit. However, at dose levels deemed safe for food irradiation, these radiations are unable to enter nuclei; as a result, food is never radioactive. Infrared and microwave radiation are other forms of radiation energy with longer wavelengths. Traditional cooking uses infrared radiation. Due to their longer wavelength, microwaves have lower energy levels but are still powerful enough to move molecules and,

Three types of ionizing radiations are approved to be used for food irradiation.

- 2.13.1. **Electron beams** generated from machine sources operate at a maximum energy of 10 MeV.
- **2.13.2. X-rays** generated from machine sources operate at a maximum energy of 5 MeV.
- **2.13.3. Gamma rays** are emitted from Co-60 or Ce-137 with respective energies of 1.33 and 0.67 million electron volts (MeV).

2.13.1. Electron beams

Electron beams are streams of very fast moving electrons produced in electron accelerators. For your better understanding, an electron beam generator is comparable to the device at the back of TV tube that propels electrons into the TV screen at the front of the tube. For irradiation using electron beams, only approved electron accelerators can be used. Electron beams have a selective application in food irradiation due to their poor penetration. They can penetrate only one and one half inches deep into the food commodity. As a result, shipping cartons (pre-packed bulk food commodities) are generally too thick to be processed with electron beams. Since electron beams are generated through machine sources, so they can be switched on or off at will and require shielding.

2.13.2. X-rays

X-rays are also generated through machine sources. X-rays are photons and have much better penetration and are able to penetrate through whole cartons of food products. To produce useful quantities of X-rays, a tungsten or tantalum metal plate is attached to the end of accelerator scan horn. The electrons strike the plate and X-rays are generated which pass through the metal plate and penetrate the food product conveyed underneath. But, remember that this X-ray machine is a much powerful version to the machine used in many hospitals and dental clinics. Since Xrays are generated through machine sources, so they can be switched on or off at will and require shielding.

2.13.3. Gamma rays

The third type of ionizing radiations approved for food processing are gamma rays that are produced from radioisotopes either Co-60 or Ce-137. Contrary to electron beams and X-rays, radioisotopes cannot be switched off or on at will and they keep on emitting gamma rays. Radioisotopes require shielding. Co-60 source is kept immersed under water when it is not in use and Ce-137 is shielded in lead. Due to their continuous operation, radioisotopes need to be replenished from time to time. Gamma rays are photons and have deep penetration ability

2.14. CONCLUSION:

You learned about the principles of food processing in this unit. which describes the conversion of components and raw materials into food that is more tasty, used right away, wholesome, convenient, and has a longer shelf life. We have also determined the many substances or variables that cause food to deteriorate. We have talked about some of the conventional techniques for preparing food to keep it from spoiling, including drying, refrigeration, and ionising radiation. The fundamental goal of all of the approaches mentioned is to slow down or stop the natural process of food degradation brought on by numerous variables in order to preserve the food. Thus, the method of food processing ensures year-round availability of food, ease of storage, transportation, and distribution, preservation of the food's nutritional value, creation of jobs, and generation of additional cash.

EXERCISE

1. Define the importance of food technology in procuring the shelf life of food products?
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2. Write down the principle of food preservation.
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3. Define the Blanching as thermal method of food processing.
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4. Write the role of pasteurization In destroying pathogenic Microbes.

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5. Define sterilization technique.

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6. Define refrigeration.

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7. Define canning processs.

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8. Define cryogenic freezing

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9. Define ionizing radiation techniques in brief.

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10. Role of gama rays in preserving the shelf life of food products.

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GLOSSARY

Acetic acid : Active ingredient in vinegar; used in food preservation.

Acid foods : Foods which contain enough acid to result in a pH of 4.5 or lower. Includes all fruits except figs; most tomatoes; fermented and pickled vegetables; relishes; and jams, jellies and marmalades.

Anearobic fermentation : Fermentation in the absence of air (secondary fermentation)

Antioxidants : Antioxidants are scavengers of particles called oxygenfree radicals. Vitamins A, E, C, and many of the carotenoids and phytochemicals are thought to be antioxidants.

Asepsis : keeping out microorganisms from food.

Blanching : The process of exposing a food product to either steam or hot water for a short time, before being placed in packages and frozen or dried.

Canning : A method of preserving food in air-tight vacuumcontainers and heat processing sufficiently to preserve the food.

Cereals : Rice, wheat, millets and their products Contaminant : an undesirable substance that is considered to make something impure or dirty.

Curing : a method of food preservation that involves soaking the food in a strong salt solution.

Dehydrating : a method of food preservation that involves removing the water from the food. (Drying food) Dhals : decorticated, split products from pulse.

Drying Food : Drying is a method of food preservation that is simple, safe and easy to learn. Drying also creates new food products such as fruit leather, banana chips, pumpkin seeds and beef jerky.

Freezer : A reach-in or walk-in food storage unit that maintains a temperature of 0°F (-18°C) or less.

Freezing : A method of food preservation involving low temperatures (-18° C), a change of state of a substance from liquid to solid.

Hermetic seal : An absolutely airtight container seal, which prevents reentry of air or microorganisms into packaged foods.

Infestation : invasion by insects and pests.

Irradiation : The treatment of food with ionizing radiation to kill microorganisms.

Low-acid foods : Foods, which contain very little acid and have a pH above 4.5. Vegetables, tomatoes, figs, all meats, fish, seafood and some dairy foods are low acid.

Oxidation : Reaction with the oxygen in the air, causes food to go bad Pasteurization : A heating process designed to destroy the most heatresistant pathogenic or disease-causing microorganism in a food product.

UNIT III: - CHEMICAL PRINCIPLES IN FOOD PROCESSING:

STRUCTURE:

OBJECTIVES :

After reading this Unit, we shall be able to:

1. Describe the basic principles and techniques of food preservation using chemicals.
2. Apply Minimal Processing of Fresh Foods
3. Comprehend the comparative advantages and efficiency of these techniques; and
4. Discuss the emerging trends in food processing and preservation.

3.0 .INTRODUCTION:

The features of several chemical food preservatives will be covered in this unit, with a focus on antimicrobial food preservatives. We will also provide you a brief overview of the various chemical preservatives allowed in processed goods as well as the maximum antibacterial levels allowed in foods. Additionally, you will learn about a number of variables that affect or decide how chemical food preservatives function.

3.1. Need for Food Preservation

It's very hard to consume food without preservatives added by manufacturers during processing unless you cultivate all of your own food and cook all of your meals from scratch. A technique for preparing food so that it can be kept for later use is called food preservation. People have been experimenting with successful food preservation techniques since the earliest times because most foods only stay edible for a short time. Early food preservation techniques resulted in the production of cheese and butter, raisins, pemmican, sausage, bacon and grain. Scientific studies showed that the main culprits for food rotting were bacteria, which are abundant in the environment. Therefore, making environments unsuitable for microbial growth is necessary for food preservation.

3.2. Techniques of Food Preservation

Food preservation methods can be divided into two categories:

• physical

• chemical

Physical techniques of preservation depend on eliminating the microbes or, at the very least, halting their growth long enough for the food to be consumed safely. The physical techniques include filtration, super high pressure, gamma irradiation, freezing, drying, canning, freezing, and high intensity white light.

Chemical food preservatives are compounds that, in certain circumstances, either prevent bacteria from growing or only delay their growth. These are introduced in incredibly small amounts and barely, if at all, change the foods' physico-chemical and organoleptic characteristics. These either function directly as microbial toxins or by lowering pH to an acidic level that inhibits microbial development.

3.3. NATURAL PRESERVATIVES:

3.3.1. SALT AND SUGAR PRESERVATION

These drugs exploit a mechanism called drying, which can also be used in other contexts. The outcome, nevertheless, remains the same. The majority of bacteria cannot survive in a rather dry environment, as we will explore later. Sugar and salt work together to do this. Available water can easily pass through the membrane of a microorganism in a non-saline environment. Water inside and outside of the cell reach equilibrium in the non-saline environment due to diffusion. Water travels through a mechanism called diffusion from low solute concentration areas to high solute concentration areas.

(A solute is any substance that can be dissolved in water).

This indicates that the amount of water leaving the cell is equal to the amount coming in. The organism needs this to take place for it to live. The cell, however, is placed in an isotonic state if salt is added to the water to create a saline environment. It indicates that more water is leaving the cell than is entering it. The bacteria either grows more slowly as a result or perhaps perishes. Salt has been utilised for thousands of years because of its drying properties. Typically, 20% salt is required to suppress bacteria. As you'll see in a moment, some microorganisms can thrive in environments with a lot of salt. Salt and sugar both work through the same mechanisms, but sugar requires roughly six times as much sugar as salt to have the same effect.

3.3.2. CURING

Curing is any of several food preservation and flavouring techniques that involve the addition of salt with the goal of osmosis-induced moisture evaporation from foods including meat, fish, and vegetables. The food becomes unfriendly for the microbial development that leads to food spoiling because curing raises the solute content in the food and subsequently lowers its water potential. Up until the late 19th century, curing was the main way of preserving meat and fish. Curing can be traced back to antiquity. Dehydration was the first method of food preservation. In addition to smoking, seasoning, heating, or the addition of mixtures of sugar, nitrate, and nitrite, many curing procedures additionally incorporate these steps.

3.3.3. SMOKING:

Early on, smoking was recognised as a way to preserve food. By burning some particular types of wood, foods are exposed to smokes. It serves two key functions: flavouring as required and preservation. Many homes in the past had smokehouses where meats like beef, gammon and bacon were smoked. Fish and meat are still preserved during smoking. After curing, most meat is smoked to aid with preservation. Formaldehyde and creosote, two antibacterial substances found in smoke, as well as the dehydration that takes place in the smokehouse, work as preservatives. Burning hickory or a related wood, such as oak, maple, walnut, or mahogany, in a light breeze or wind produces the smoke.

3.4. CHARACTERISTICS OF CHEMICAL PRESERVATIVES

The Food, Drug, and Cosmetic Act permit for the use of chemical preservatives in foods if the chemical is:

1. Generally recognized as safe (GRAS) for such use; or if a food additive is covered by food additive regulations prescribing conditions of safe use.

2. Not used in such a way as to conceal damage or inferiority or to make the food appear better or of greater value than it is.

3. Properly declared on the label of the food in which used.

4. It should be food grade.

5. It should perform its intended function.

6. It should be used in accordance with good manufacturing practices and, where applicable, in accord with existing food additive regulations.

According to rules, a food manufacturer must get approval from Government regulatory authorities before using a new preservative, or before using a previously approved preservative in a new way or in a different amount. In its petition for approval, the manufacturer must demonstrate that the preservative is safe for consumers, considering:

• the probable amount of the preservative that will be consumed with the food product, or the amount of any substance formed in or on the food resulting from use of the preservative

• the cumulative effect of the preservative in the diet

• the potential toxicity (including cancer-causing) of the preservative when ingested by humans or animals.

- A preservative may not be used to deceive a consumer by changing the food to make it appear other than it is. For example, preservatives that contain sulfites are prohibited on meats because they restore the red colour, giving meat a false appearance of freshness.

• The food additive regulations require the preservative to be of food grade and be prepared and handled as a food ingredient.

• The quantity added to food must not exceed the amount needed to achieve the manufacturer's intended effect.

Regulations governing the use of nitrites show how closely the use of additives is scrutinised. Nitrites work as antimicrobials in meat to stop the growth of the bacterial spores that cause botulism, a fatal food-borne sickness. Nitrites are employed in conjunction with salt. Numerous red meat, poultry, and fish products employ nitrates as preservatives, flavours, and colour stabilisers. Since sodium nitrite's original certifications for a number of uses were given, safety issues have appeared. Certain amines (derivatives of ammonia) in food can react with nitrite salts to create nitrosamines, several of which are known to cause cancer.

A food maker who wants to utilise sodium nitrites must demonstrate that, when used as intended, the additive won't cause dangerous levels of nitrosamines to form in the product. For instance, laws mandate that 100 to 200 parts per million of sodium nitrite, an antibiotic used to prevent the production of botulinum toxin in smoked fish, must be present. To prevent the production of nitrosamines, additional antioxidants may also be included. Examples of these include sodium ascorbate and sodium erythorbate.

3.5. CLASSIFICATION OF PRESERVATIVES

Preservatives can be categorized into following types:

3.5.1. Antimicrobials that inhibit growth of bacteria, yeasts, or molds.

3.5.2. Antioxidants that slow air oxidation of fats and lipids, which leads to rancidity.

3.5. 3. Antienzymatic that blocks the natural ripening and enzymatic processes that continue to occur in foodstuffs after harvest.

3.5. 4. Preservatives from natural products.

3.5.5. Traditional preservatives

We will discuss the first type of preservatives in detail but before that brief description of other types is given below for the sake of awareness.

3.5.2. **Antioxidant Preservatives**

They prevent food from going rancid, browning, or getting black patches since they are antioxidants. Foods that are rancid may not make you ill, but they taste and smell unpleasant. The process that happens when food and oxygen mix in the presence of light, heat, and some metals is suppressed by antioxidants. Additionally, antioxidants reduce the loss of some vitamins and the deterioration of several critical amino acids, which are the building blocks of proteins.

Antioxidant preservatives, such as butylated hydroxytoluene, butylated hydroxyanisole, tert-butylhydroquinone, and propyl gallate, stop the chemical breakdown of food that happens in the presence of oxygen. Unsaturated fatty acids in oils and lipids are particularly susceptible to autooxidation. In this process, a free radical initiates peroxide formation at fatty acid double bonds. The chain reaction propagates to other double bonds, and aldehyde, ketone, and acid-termination products eventually build up to create the rancid offflavors characteristic of oils and fats gone bad. Antioxidant preservatives sop up the free radicals that help initiate and propagate these reactions.

3.5.3. Preservatives that Targets Enzymes

These are preservatives that go after the food's own metabolising enzymes that continue to function even after harvest. When an apple or potato is chopped, the enzyme phenolase, for instance, gets to work. The exposed surface darkens. Acids that make the pH too low for phenolase to function properly include citric acid and ascorbic acid (vitamin C). Many enzymes require metal cofactors, which can be eliminated by using metal-chelating substances like EDTA (ethylenediamine tetraacetic acid). Additionally, chelators make it challenging for bacterial and fungal enzymes to function.

3.5.4. Preservatives from Natural Products

When microbes compete with one another for nutrition and space, they develop their own chemical defences, which is how some of the most recent antimicrobials are discovered. Bacteriocins, such as nisin and natamycin, are used to preserve cheese and are obtained from microbes.

In pasteurised process cheese spreads including fruits, vegetables or meats, nisin is used to prevent the growth of Clostridium botulinum spores (the source of botulism) and the production of toxin at levels that don't go above good manufacturing practise. In this instance, current good manufacturing practise calls for using an amount of the ingredient that results in a final good that has no more than 250 p.p.m. of nisin.

In other nations, it is also utilised in foods with high moisture content and low fat content, fermented drinks like beer, canned goods, frozen desserts, and fresh and blended milk. Numerous gram-positive microorganisms, such as Listeria enterococcus, Bacillus sporothermodurans, and Clostridium, are thought to be well controlled by nisin.

It is ineffective when used alone against gram-negative bacteria (such as E. coli), yeasts, and moulds. When combined with other preservatives, research indicates that it might be effective against some gram-negative bacteria.

3.5.5. Traditional Chemical Food Preservatives

Common salt and sugar are two conventional chemical food preservatives that are also used in fruit and vegetable processing. used in brining vegetables is regular salt. Their use is unrestricted. Foods preserved by high sugar concentrations, such as jams, preserves, syrups, and juice concentrates, are known as sugars (sucrose, glucose, fructose, and syrups). It works by causing sugar to interact with other substances or procedures like heating and drying. Their use is unrestricted.

3.5.1. ANTIMICROBIAL PRESERVATIVES

In Table 3.1, a list of commonly used chemical food preservatives is provided.

Agent	Acceptable Daily intake (mg/Kg body weight)	Commonly used levels (%)	Typical usage
Sorbic acid Potassium sorbate	25	0.05-0.2	fruits; vegetables; pickled products; jams, jellies
Benzoic acid Sodium benzoate	5	0.03-0.2	Vegetable pickles; preserves; jams; jellies; semi-processed products
Propionic acid Sodium propionate	10	0.1-0.3	Bakery goods, cheese spread, fruits, vegetables
Methyl paraben Ethyl paraben Propyl paraben	10	0.05-0.1	Bakery goods, fruit products; pickles; sauces
Lactic acid	No limit	No limit	Fermented meat, dairy and vegetable products, sauces and dressings, drinks.
Citric acid	No limit	No limit	fruit juices; jams; other sugar preserves
Acetic acid	No limit	No limit	vegetable pickles; other vegetable sauces, chutney
Sodium nitrite	0.2	0.01-0.02	Meat products

Sulphur dioxide	0.7	0.005-0.2	fruit juices, dried / dehydrated fruits and vegetables, semiprocessed products

3.5.1.1. SODIUM BENZOATE AND BENZOIC ACID

The substance with antibacterial qualities is called benzoic acid, and it is naturally present in cranberries, prunes, greengage plums, cinnamon, mature cloves, and apples. When sodium benzoate is dissolved in water, benzoic acid is produced. Because sodium benzoate is 180 times more soluble in water than benzoic acid, it is chosen over benzoic acid in many food applications. This preservative clearly has a pH effect; the lower the pH, the more effective it is.

Only foods that are naturally acidic or that have been artificially acidified have a pH below 4.5, making them suitable for use with sodium benzoate. For instance, at pH 3.0, just around 0.05% of the substance is necessary to have the same antibacterial action as pH 4.0 and 0.1% benzoate. When the pH is between 2.5 and 4.0, maximum functioning takes place. In addition to being used in fruit goods, jams, relishes, drinks, dressings, salads, pie and pastry fillings, icings, olives, and sauerkraut, sodium benzoate also has anti-yeast, anti-bacterial, and anti-mold properties.

White granular or crystalline powder, odourless, and reasonably priced (at the usage level), sodium benzoate should be kept in waterproof containers and kept in a cool, dry location. To prevent potential off odours in some products, it should be used in small amounts. The legal upper limit is set at 0.1%.

3.5.1.2. SORBATES

This group of substances can be found as sorbic acid, potassium, sodium, or calcium sorbates. The substance having antibacterial capabilities is sorbic acid, however due to variations in solubility, its salts (sorbates) are frequently used. The potassium salt of sorbic acid, potassium sorbate, is far more soluble in water than the acid itself. It is a cheap (at the usage level), white crystalline powder with essentially no discernible flavour at typical usage concentrations. Sorbate is used in the wine-making process to stop refermentation. The legal maximum limit is 0.1%. It is the most frequently used food preservative in the world and, when dissolved in water, creates sorbic acid. Up to pH 6.5, it is effective, but as pH falls, effectiveness rises. Since it only has around 74% of sorbic acid's antibacterial activity, larger quantities are needed to achieve the same effects.

It is frequently used in a range of foods, including cheese, dips, yoghurt, sour cream, bread, cakes, pies, and fillings, baking mixes, doughs, icings, fudges, toppings, beverages, margarine, salads, fermented and acidified vegetables, olives, fruit products, dressings, smoked and salted fish, confections, and mayonnaise. It is effective against yeasts, moulds, and some bacteria.

The pH of a food product will be raised by roughly 0.1 to 0.5 pH units when sodium benzoate and/or potassium sorbate are added, depending on the amount, pH, and kind of product. To maintain a safe pH, more pH adjustments may be required. Together, sorbate and benzoate are employed in many food products to offer better defence against a larger range of bacteria. This only makes sense if the product's pH is lower than 4.5.

3.5.1.3. Propionic acid

Natural sources of propionic acid include grains, violet leaves, strawberries, and apples. It is created in concentrations as high as 1% during the fermentation process of various cheeses, including Swiss cheese, which prevents the growth of mould. The bacteria Bacillus mesentericus and its spores, which result in rope, an unpalatable condition in baked foods, are both resistant to the acid. It is an oily liquid that dissolves in water and has a faintly unpleasant, rotten aroma. Additionally, it is combustible and caustic, necessitating cautious handling. In the United States, propionic acid and its salts, sodium and calcium propionates, have been given the GRAS (Generally Recognised As Safe) designation for use in food.

They are the perfect option for goods that contain commercial yeast because their antibacterial action is focused on moulds and rope bacteria while having little to no impact on yeast. Propionate's efficiency, like that of other preservatives, is influenced by the pH of the food, with 5.5 pH being the maximum effective range. Although they are also beneficial in cheese, non-alcoholic beverages, confections, fillings, frostings, fresh dough, pizza crust, puddings, gelatins, jams, jellies, and various meat products, they are mostly utilised as mould and rope inhibitors in bread. The crystals of sodium and calcium salts are clear and white and have a slight cheese-like flavour. The calcium salt is less water-soluble than the sodium version.

Because the presence of calcium ions (if you were to use calcium propionate) would disturb the leavening process, sodium propionate is advised in baked goods that employ baking powder and baking soda instead of yeast as the leavening agent. In baked goods containing yeast, including breads and rolls, calcium propionate is recommended because it boosts the nutritional content of the item. Propionates and propionic acid are typically used at a level of 0.1 to 0.4%. According to federal laws, the maximum level for flour, white bread, and rolls is 0.32% based on flour weight; 0.38% based on flour weight for whole wheat goods; and 0.3% based on flour weight for cheese products. The pH of a food product will increase by roughly 0.1 to 0.5 pH units when sodium and calcium propionate are added, depending on the amount, pH, and kind of product. To maintain a safe pH, more pH adjustments may be required.

3.5.1.4. Parabens

Esters of para-hydroxibenzoic acid make up the parabens. Methyl and propyl parabens, which fall under the GRAS classification in the United States, are the two most used esters. The permitted maximum concentration is 0.1%. They are especially effective at combating mould and yeast. At room temperature, parabens are white granules with a little fragrance that are only moderately soluble in water. By raising the water's temperature to 71.1°C–82.2°C, the solubility is significantly boosted. Propyl paraben is more effective against moulds, whereas methyl paraben is less effective. Typically, combinations of 2 to 3 parts methyl paraben and 1 part propyl paraben are used to offset these discrepancies.

The efficiency of parabens at higher pH levels, from 3 to 8, and their stability at high and low temperatures, including steam sterilisation, are important benefits. Despite these advantages, parabens are less frequently utilised than other antibacterial agents, most likely because of their higher cost and flavor-related drawbacks. Applications range from beverages, flavour extracts, food colours, fruit goods, jams, jellies, preserves (artificially sweetened), gelatin, marinated and smoked fish, pickles, salad dressings, syrups, wine, and olives to bakery items (formulated without yeast)..

3.5.1.5. Lactic acid

This acid, which is produced by the microbial breakdown of carbohydrates in foods like sauerkraut and pickles, is the major byproduct of many food fermentations. Such fermentations reduce the pH to levels where spoiling organisms, such as putrefactive anaerobes and bacteria that create butyric acid, cannot develop. Additional preservatives like sorbate and benzoate can be used to prevent the growth of moulds and yeasts that can flourish at such pH levels.

3.5.1.6. Acetic acid

As a general preservative, acetic acid prevents the growth of many types of bacteria, yeasts, and to a lesser extent, mould. It is also a byproduct of the fermentation of lactic acid, and even at the same pH levels, its preservation activity is stronger than that of lactic acid. Pickles, sauces, and ketchup are just a few examples of the goods that use vinegar (acetic acid) most frequently.

3.6. GASEOUS CHEMICAL FOOD PRESERVATIVES

3.6.1. Sulphur dioxide and sulphites

Sulphur dioxide (SO2) has been used as a wine preservative and fumigant for many years. It is a non-flammable, colourless, suffocating gas with a strong odour that dissolves readily in cold water (85 g in 100 ml at 25°C). Sulphurous acid, bisulphite, and sulphite ions are produced when sulphur dioxide and its different sulphites are dissolved in water at a low pH. 50–68% of the active sulphur dioxide is present in the different sulphite salts. In water, a pH-dependent equilibrium develops, and as the pH drops, so does the proportion of SO2 ions. The antibacterial action is greatest at pH levels under 4.0. Sulphur dioxide is employed as a gas or in the powder forms of its salts, sulphite, bisulphite, and metabisulphite.

Sulphur can either be released from the compressed liquefied form or burned to create the gaseous form. Compared to bisulphites, which in turn exhibit more stability than sulphites, metabisulphites exhibit greater resistance to oxidation.

D. Mode of action

Sulfites prevent the growth of microorganisms in a variety of ways. They interfere with some metabolic pathways, disrupt cellular transport systems, and react with the energetically dense molecule adenosine triphosphate. Other antimicrobials affect the permeability of bacteria cell walls or membranes, or even obliterate the genetic material. In addition to being antibacterial, sulphur dioxide prevents fruit deterioration processes. By preventing both enzymatic browning and a nonenzymatic browning reaction involving reducing sugars and amino acids known as the Maillard reaction, it prevents raisins and other dried fruits from losing their light colour. Raisins undergo a process that darkens them, changes their flavour, and depletes them of vital amino acids.

E. Uses

Sulphites are used to stop or lessen discoloration of fruits and vegetables with light-colored skins, like dry apples and dehydrated potatoes. These are combined with Hawaiian coconut syrup, balsamic vinegar, red wine vinegar, dried apricots, dried sweet potatoes, and sun-dried tomatoes. These are frequently used to extend the shelf life of fruit juices as well. Due to the fact that they prevent bacterial growth without obstructing yeast growth, they are also utilised in the production of wine. Other applications for sulphites include whitening food starches and guarding against rust and scale in steam boiler water that will come into contact with food. Sulphites are one of the ingredients used to make the cellophane used in food packaging.

F. Precautions

Because sulphites degrade thiamin (vitamin B1), the FDA forbids their use in foods that are significant sources of the vitamin, such as enriched flour. Although they are safe for the vast majority of people, they induce severe allergic reactions, especially in asthmatics. Regardless of the quantity in the finished product, sulphites employed expressly as preservatives are required to be disclosed on the label by the FDA. If present at concentrations of 10 parts per million or more, sulphites employed in food processing but not acting as preservatives in the finished food must be disclosed on the label. Sulphites are prohibited by the FDA from being used on fruits and vegetables intended for raw consumption. These were employed to preserve the fresh food's colour and crispness.

3.6.2. Carbon dioxide (CO2)

Colourless, odourless, and incombustible, CO_2 has an acidic flavour and smell. In actual practise, it is either consolidated as dry ice or sold as a liquid under pressure (58 kg per cm^3). In several nations, carbon dioxide is used as a solid (dry ice) to transport and store food items at low temperatures. Along with lowering the temperature as it sublimes, gaseous CO_2 also stops the growth of psychrotrophic microbes and avoids fruit and vegetable deterioration, among other things. It serves as a direct addition when fruits and vegetables are stored. The proper ratio of O_2 and CO_2 slows respiration, ripening, and the formation of mould and yeast in the controlled/modified environment storage of fruit and vegetables.

The end result is an extended storage period for the products for both transit and off-season consumption. The type of the product, variety, environment, and degree of storage all play a role in determining the amount of CO_2 (5–10%).

3.6.3. Chlorine

The most often used chemical sanitizer in the food business is chlorine in its different forms. These chlorine compounds include chlorine gas (ClO_2), sodium hypochlorite (NaOCl), calcium hypochlorite ($Ca(OCl)_2$), and calcium hypochlorite.In procedures including product cleaning, transporting, and cooling heat-sterilized cans, as well as in sanitising solutions for equipment surfaces, these substances are employed as water adjuncts. Drinking water disinfection and equipment sanitation are two significant uses for chlorine and its derivatives.

3.6.4. Nitrites and Nitrates

Mostly in packaged meats, nitrates and nitrites are employed. To meats like gammon, bacon, hot dogs and smoked salmon, sodium nitrate is added. The body converts nitrates from nitrates, which inhibit the growth of microorganisms, particularly those responsible for botulism poisoning. They are the Clostridium botulinum bacterium's main chemical defence against the food industry.

Additionally, it maintains the red hue of cured meat and prevents it from turning grey. Nitric oxide myoglobin is created when the protein myoglobin reacts with nitrates, which are easily converted to nitrites. This is changed into the stable pink pigment nitrosohemochrome during cooking. They also give cured meat a rosy, fresh colour.

This chemical preserves the meat's red hue and gives it the illusion of being fresh. Because of this, even though its excessive usage is prohibited in many nations, nitrites are a popular preservative of meat processors.

Precaution

Certain amines in food can react with nitrite salts to create nitrosamines, which are known to cause cancer. Nitrosamine production is inhibited and the issue with nitrosamines is lessened by the use of sodium ascorbate or sodium erythorbate. Because of refrigeration and limitations on the quantity utilised, the usage of nitrite and nitrate has significantly decreased. Although the risk posed by nitrite and nitrate is minimal, it is always preferable to consume fresh meat and meat products.

3.7. GENERAL RULES FOR CHEMICAL PRESERVATION

Chemical food preservatives should only be used at the dosage required for normal preservation, and not more.

• "Reconditioning" chemically preserved food, such as adding a new preservative to arrest an existing microbial deterioration, is not advised.

• The use of chemical preservatives MUST be carefully restricted to those compounds accepted by national and international norms and legislation as having no negative impact on human health.

Factors which determine/ influence the action of chemical food preservatives

a) Factors related to micro-organisms:

•In general, you can base your decisions on the data listed below:

• Sulphur dioxide and its derivatives are regarded as "universal" preservatives since they operate as an antiseptic against both yeasts and moulds and bacteria;

• The preservation activity of benzoic acid and its derivatives is stronger against bacteria than it is against yeasts and moulds;

• Sorbic acid affects moulds and some types of yeast; at greater dosages, it also affects bacteria, excluding lactic and acetic ones;

• The effectiveness of the chemical preservative is dependent on the initial concentration of microorganisms in the treated product.

• If the product has been contaminated as a result of irresponsible hygienic handling during the initial process or an impending change, the efficiency will be lower.

Therefore, the preservative dose level could be decreased with a low initial concentration of microorganisms in the product.

b) Factors related to the product:

The product's chemical makeup is.

• The product's pH value: Most chemical preservatives work more effectively at lower pH levels, or when the medium is more acidic.

• The product's physical presentation and the thickness at which it is cut: The chemical preservative's dispersion in food affects how well it is absorbed and diffused by microorganisms through their cell membranes, which influences the preservation effect. Therefore, the product's preservative activity increases with decreasing product slicing. Foods that are viscous (such as concentrated fruit juices, etc.) slow down the dispersion of preservatives.

c) Miscellaneous factors

Temperature, Time: At preservative dosage levels used in industrial practise, the time required to achieve "chemical sterilisation" is a few weeks for benzoic acid and shorter for sulphuric acid. Chemical preservative dosage level will be established as a function of product temperature and characteristics of the micro-flora.

3.11. Minimal Processing of Fresh Foods

The concept of minimal processing applies mostly to vegetables, fruits and juices. The principles and applications of hurdle theory are used together with the development of emerging techniques for the minimal fresh processing or fresh-cut industry to improve the quality, safety and shelf-life of plant-derived commodities in order to satisfy increasing consumer demand.

There is growing interest in this concept in the food industry as the consumer demand for healthier and fresher food products is rising every year. The main spoilage changes that affect minimally fresh processed fruits and vegetables, as well as how the traditional processing and preservation techniques solve these problems, are tackled in this exciting new branch of food technology. Also the need for seeking alternatives or secondary techniques which use mild but reliable treatments in order to achieve fresh-like quality and safe products with a high nutritional value is considered. Additionally, there is focus on the keys for the production of safe foods, which include screening materials entering the food chain, suppressing microbial growth and reducing or eliminating the microbial load by processing and preventing post-processing contamination. Some successful combinations of sub-inhibitory processes, based on the application of a combination of various mild treatments, take advantage of the synergisms of the different preservation hurdles known as ‘hurdle technology’. The success of the new technologies also depends on a good understanding of the physiological responses of microorganisms to stresses imposed during food preservation.

Emerging technologies like high pressure processing, pulsed electric field processing, pulsed light processing, ohmic heating, etc. are used for keeping microbial and sensory quality of minimally fresh processed fruits, vegetables and juices especially relating to disinfection of the products. Novel modified atmosphere packaging, hydrogen peroxide, ultraviolet-C radiation, ozone, acidic electrolysed water, biocontrol cultures, organic acids, chlorine dioxide or hot water treatments have been tried to ensure food safety and quality.

As consumers increasingly perceive fresh food as healthier than heat-treated food, it motivates a general search for food production methods with reduced technological input. This phenomenon was observed over the last few years since the per capita consumption of fresh fruits and vegetables has increased significantly over the consumption of processed vegetables such as canned vegetables. However, a food which meets nutritional requirements is unlikely to be accepted by consumers if they do not like the flavour or other quality attributes, and herein lies another challenge to food technologists.

Fruit & vegetables are the major dietary sources of substances with antioxidants and free radical scavenging properties like anthocyanins and other phenolic compounds, of high importance from the human nutritional point of view. Carotenoids, tocopherols and vitamin C are also appreciated due to their possible role in the prevention of several human diseases. Advances in agronomic, processing, distribution and marketing technologies, as well as the current preservation techniques, have enabled the produce industry to supply nearly all types of high-quality fresh fruit and vegetables to those who desire and are willing to purchase them year round. Despite the benefits derived from eating raw fruits and vegetables, safety is still an issue of concerns as these foods have long been known to be vehicles for transmitting infectious diseases.

Whole fruit and vegetable products are highly susceptible to deterioration between harvest and consumption. Since minimal processing damages plant tissues, leading to additional quality losses, the derived fresh-cut commodities are in fact more sensitive to disorders than the original. The main features are the presence of cut surfaces and damaged plant tissues, the minimal processing that cannot guarantee microbial stability of the product, the active metabolism of the plant tissue and the limited shelf life of the product. Therefore, deterioration of minimally fresh processed fruits and vegetables is mainly due to further physiological ageing, biochemical changes and microbial spoilage which originate changes in respiration, ethylene emission, transpiration and enzymatic activity of the living tissues after harvesting and processing. Many of the compositional changes influence their colour, texture, flavour and nutritive value.

As mentioned, the traditional processing of this kind of product usually consists of a sequence of operations (trimming, peeling, cutting, washing/ disinfection, drying and packaging) and, generally, the extension of the shelf life depends on a combination of correct chilling treatment throughout the entire chill chain, dips in anti-browning solutions, optimal packaging conditions (usually MAP) and good manufacturing and handling practices in well designed factories. Additionally, some authors have proposed the use of edible coatings in combinations with anti-browning compounds to improve the colour preservation of fresh-cut fruit.

Once these traditional processing and preservation techniques have been able to provide food products with acceptable sensorial and microbial quality, the next step forward is to design mild but reliable treatments in order to achieve fresh-like quality and safe products with a high nutritional value. Therefore, the minimally fresh processing industry is currently seeking alternatives or secondary technologies to maintain most of the fresh attributes, storage stability and above all safety of fresh processed fruits and vegetables, meanwhile extending their shelf-life, although long shelf-life is not the most important selling argument anymore, with the market trends tending towards more fresh-like products.Production of safe food includes screening materials entering the food chain, suppressing microbial growth and reducing or eliminating the microbial load by processing and preventing post-processing contamination.

3.12. Other Emerging Techniques

3.12.1. Modified atmosphere packaging (MAP)

It is well known that MAP has been successfully used to maintain the quality of minimally fresh processed fruits and vegetables. However, novel MAP technologies that allow an extension of the shelf-life are still much demanded by producers and distributors. It was observed that exposure to high O2 alone did not strongly inhibit microbial growth and the results were highly variable. On the other hand, many authors have found that superatmospheric O2 (higher than 70kPa O2), when combined with increased CO2 concentrations, inhibits enzymatic discoloration and microbial growth in fresh-cut vegetables and prevents anaerobic fermentation reactions. Therefore, it could be considered as a good alternative to conventional MAP with moderate-to-low O2 and high CO2 levels (Day, 2001). The development of new packaging materials will allow definitive avoidance of anaerobic conditions and a reduction in respiration rate, ethylene emissions, browning as well as weight loss in order to keep the fresh properties of minimally fresh processed fruits and vegetables longer, attenuating undesirable changes in sensory quality and controlling microbial growth. It is known as ‘active’ and ‘smart’ packaging, which responds actively to changes in the food package. As an example, smart packaging can now include materials designed to absorb or emit chemicals during storage, thereby maintaining a preferred environment within the package which maximizes product quality and shelf-life. Therefore, the use of non-conventional MAP combined with antimicrobial, moisture absorbers and edible films or those films fitted with porous substrates covered with side-chain crystallizable polymers or with an O2 emitter and/or CO2 or C2H4 scavenging devices will also have many potential applications.

3.12.2. Genetic Engineering

The possible use of genetic engineering to develop higher production and more resistant plant foods (GM Foods) is relatively well known. Currently, this technology is being used to introduce desirable attributes such as improved colour, aroma, flavour and taste of different fruit and vegetable products. In fact, the first transgenic product introduced as a food commodity was a tomato with reduced polygalacturonase activity. Although the huge advance of these techniques was in the last decade, there is still a lack of published information about the development of genetically modified fruit and vegetables which overcome some relevant problems of the post-harvest science such as chilling injury resistance, longer storage duration and pathogen resistance. Therefore, much more effort should be done in this area and recent advances in functional genomics should bring candidate genes to manipulate. In addition, the industry has to take into account the lengthy food safety studies required by legislation in many countries, particularly, the European Union.

3.13. Emerging Technologies For Minimally Processed Fresh Fruit Juices

The market for minimally processed refrigerated fruit juices, like ready-to-eat plant foods, has experienced substantial growth over the past few years. Traditionally, fruit juices were subjected to heat treatments between 60 and 100 degree C for a few seconds. However, by using this technology, undesirable reactions may take place producing unwanted changes in the product or by-product formation, which decrease the overall quality of the juices. Therefore, the development of emerging technologies, which use a lower temperature to the traditional heat treatment and guarantee a final food product which preserve the fresh properties of the fruit juices as much as possible, is needed. Their success relies on a mild preservation treatment (generally, heat) combined with chilling to keep flavour and nutritional properties. Some researchers contrast minimal processing techniques with thermal processing, however, developments in thermal technologies have been considered ‘minimal’ where they have minimized quality losses in food compared to conventional thermal techniques.

The emergence of novel spoilage microorganisms in juices also poses a new challenge for the correct preservation of these food products. Fruit juices have been considered for many years susceptible to spoilage only by yeast, moulds and lactic acid bacteria. Their acid pH, lower than 4.0 in most cases, was considered sufficient to prevent growth of almost all spore-forming microorganisms. This fact has allowed the fruit beverage industry to apply successfully a hot -fill-hold process to pasteurize these products. However, in the last few years an increasing number of incidents of spoilage of acid foods, such as fruit juices, has been reported. Most of these spoilage incidents have been related to spore-forming thermo - acidophilic microorganisms. Spoilage caused by this kind of microorganisms is difficult to detect. The juice appears normal or has light sediment and no gas is produced. Often, the only evidence of the alteration is a ‘medicinal’ or ‘phenolic’ off-flavour.

Only in the last ten years has there been any real recognition of mild preservation treatments as non-thermal methods to preserve food products and there is a growing interest for non-heat treatment of juices. The juices can be processed by using pulsed electric fields, high hydrostatic pressure, high intensity pulsed light, irradiation, new chemical and biochemical additives and, of course, the hurdle technology. The use of membrane disrupting novel preservation techniques, such as ultrasound, high pressure or pulsed electric field is based in their potentially synergistic effects with chill storage or mild heat treatment.

3.13.1. Pulsed Electric Fields

Pulsed electric fields (PEF) have been shown to be able to reduce the microbial population of refrigerated fruit juices, such as apple or orange and carrot juice. At the same time, this technology induces sub-lethal damage in bacteria, which causes a significant delay in their ability to grow and spoil the product. However, PEF can only be applied to liquid products. While the shelf-life of the orange juice processed with PEF was extended to 14 days, the non-treated juice was not acceptable after 4 days of storage. However, to prevent spoilage of orange-carrot juice, it would be necessary to combine an efficient PEF treatment with chilling temperatures during the distribution and storage periods and to guarantee low initial concentrations of contaminating bacteria in fresh-squeezed juice.

3.13.2. High Hydrostatic Pressure or High Pressure Technology

The application of high hydrostatic pressure for processing food products consists of a pressure treatment in the range of 4000-9000 atmospheres. The high hydrostatic pressure is used to inactivate microbial growth as well as certain enzymes to prolong the shelf-life of the food products, although the microbial inactivation will depend on the pH, food composition, osmotic pressure and the temperature of the environment. It is known that Gram negative bacteria are inhibited at lower pressure than Gram positive bacteria. The inhibition of microbial spores can be managed by combining the high pressure treatment with chilling temperatures.

3.14:CONCLUSION:

The history of food preservation and processing is as old as that of human civilization. Need for food security, being an integral part of human development, has contributed to the gradual development of food processing and preservation techniques and technologies. Food Technology/ Processing is a multi-disciplinary science requiring in-depth knowledge of several basic and applied sciences. Some of the major food processing techniques of modern times are based on addition of heat/ thermal processing, drying/ removal of moisture, cooling/ removal of heat and addition of preservatives. Some of the important reasons for resorting to food processing & preservation are: conversion of basic foods into forms that render them directly eatable, increasing the shelf life of foods-especially the perishables, making seasonal foods available round the year and making raw foods safe to eat. Inspite of all the advances of food science and technology, there are still significant number of cases of food borne illnesses and contaminations even in advanced nations resulting in considerable productivity loss, medical costs and loss due to food recalls from the market. Therefore food safety is a major issue especially when it comes to processed food commerce and international trade. Food processing and preservation therefore plays a vital role in the long chain between farm and fork. There is inevitably some loss of nutrition and quality during processing of foods as compared with raw foods. This has led to the modern trend of minimally processed foods and of the HACCP techniques. The real challenge for the food technologist is to carry out food processing efficiently and hygienically with minimal losses in quantity and quality, using minimal quantities of energy, water and other inputs, while ensuring that the final product is tasty, nutritious and safe

EXERCISE

1. Define food processing and food preservation.
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2. List the major causes of food deterioration/spoilage
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3. Write the principle of chemical preservation
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   …………………………………………………………………………………………
4. Mention the major advantages of food processing
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5. Different preservation techniques commonly used today, include:
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6. Define various natural preservatives used.
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7. Write down the characteristics of chemical preservatives
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8. Define curing
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   ………………………………………………………………………………………
9. Define smoking
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10. Write the uses of Acitic acid and Lactic acid as preservatives.

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11. Write in brief about gaseaous preservatives
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12. Define general rules of chemical preservatives
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13. Define MAP
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14. Write in your own words about genetically modified food products
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15. Define High Hydrostatic Pressure Or High Pressure Technology
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KEY WORDS

Food Spoilage : Undesirable change in flavours, odours appearances or texture of food.

Preservation : Safeguarding

Preservative : Additive

Anti microbial : Which act against microorganisms.

Anti oxidant : Which removes the oxygen.

GRAS : Generally recognized as safe.

Absorption : Uptake of moisture by dry foods.

Acid Food : A food with a pH of less than 4.6 and a water activity (aw) equal to or greater than 0.85.

Additives : Chemicals added to improve their eating quality or shelf-life.

Food Preservation : is the process of treating and handling food in such a way as to stop or greatly slow down its spoilage and to prevent food borne illness while maintaining the food item's nutritional value, texture and flavor.

Food Processing : is the set of methods and techniques used to transform raw ingredients into food for consumption by humans or animals. The food processing industry utilises these processes. Food processing often takes clean, harvested or slaughtered and components convert into attractive and marketable food products. Various techniques are used for this purpose.

HACCP : Hazard Analysis and Critical Control Points. Heat Sterlization : Destruction of the majority of microorganisms in a food by heating.

Latent Heat : Heat taken up or released when a material undergoes a change of state.

Pulsed Electric Field : Application of electric field with a strength in the Processing range of 12-35 kV cm-1 to a liquid food in a short pulse (1-100 ps) produces lethal effect on microorganisms.

Thermal Centre : The point in a food that heats or cools most slowly.

Thermal Death Time : The time required to achieve a specified reduction in microbial numbers at a given temperature.

Ultra High Temperature- : Processing/ Heat sterilization at above 135o C for a ture (UHT) Treatment few seconds.

Water Activity (aw) : It is defined as the ratio of the vapor pressure of water in a material (p) to the vapour pressure of pure water (po) at the same temperature. It is ratio of moisture content of the product and the relative humidity of air surrounding it.

SOME USEFUL BOOKS

B. Sivasankar. (2004). Food Processing and Preservation Prentice-Hall of India Pvt. Ltd

Desrosier, N.W. (1963). The Technology of Food Preservation, AVI Publications.

Eckles & Eckles. (1991). Technology of Milk & Milk Products, AVI Publications.

Gaurav Tewari (Ed) and Vijay Juneja (Ed). (2001). Advances in Thermal and Non-Thermal Food Preservation; ARS, USDA.

Gustavo V. Barbosa-Canovas (Ed), Grahame W. Gould (Ed). (2000). Innovations in Food Processing (Food Preservation Technology Series) : CRC Publishers

Mahindru, S.N., (2000). Food Additives; Published by Tata McGraw Hill.

Ramaswamy, H.S. & Michele Marcott. (2005). Food Processing – Principles & Applications; CRC Publications.

Vijaya Khader.,2020., textbook of Food Science and Technology., Indian Council of Agriculture Research, New Delhi.

BLOCK-2 PROCESSING TECHNOLOGY OF CEREALS, PULSES, FRUITS

AND VEGETABLES

Block 2 comprises of detailed description of processing technology of cereals, pulses, fruits and vegetables and oilseeds processing. The whole block is grouped in four units. Unit IV deals with processing of cereals in which processing of wheat barley rice and their by products were discussed. Unit V deals with the processing techniques of pulses and oilseeds. Unit VI comprises of processing technology of fruits and vegetables. Unit VII consist the detailed information of processing technology of milk and milk products.

UNIT IV: PROCESSING TECHNOLOGY OF CEREALS – WHEAT,

BARLEY AND RICE AND ITS BY PRODUCTS

STRUCTURE:

4.0: Introductionof Processing Technology

4.1: Structure and Composition of Cereals

A. Structure
B. Nutritional composition

4.2 :Wheat Processing:

- **4.2.1. Milling**
- **4.2.2. Cleaning**
- **4.2.3. Conditioning / Tempering**
- **4.2.4. Separation of flour**
- **4.2.5. Milling of durum or semolina;**
- **4.2.6. Technology of pasta products**
- **4.2.7. Fractionation of flour**
- **4.2.8. Bread Making Process**
- **4.2.9. Biscuits Making Process**
- **4.2.10. Technology of Cakes**

4.3: Barley Processing.

- **4.3.1. Malting;**
- **4.3.2. Chemistry of malting**
- **4.3.3. Steeping**
- **4.3.4. Germination**
- **4.3.4. kilning**

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4.4: RICE PROCESSING,

- **4.4.1. Rice Milling**
- **4.4.2. Milling Procedure**
- **4.4.2.1. Small scale milling**
- **4.4.2.2. Large scale milling**
- **4.4.3.** ***Cleaning***
- **4.4.4.** ***Hulling/Shelling***
- **4.4.5.** ***Scouring/Pearling/Whitening***
- **4.4.6.** ***Polishing***
- **4.4.7. Parboiling of Rice**
- **4.4.8. Rice based instant foods.**

OBJECTIVES

After reading this Unit, we shall be able to:
- List out foods from plant sources;
- Describe milling of cereals, Barley, pulses and oilseeds.
- To know about the baking technology of bread biscuits and cakes.

4.0. Introduction of processing technology

After the green revolution, India has achieved a level of self-sufficiency in the production of grains, pulses, and oilseeds. Cereals are plants that produce edible grains, such as oats, wheat, maize and barley. Cereal grains are the fruit of grass (Gramineae) family plant species. The majority of the world's dietary calories and roughly half of its protein come from cereal grains. Additionally, they are a good source of micronutrients like calcium, iron, and group B vitamins. The vast majority of people in the world consume cereals in huge quantities, either in their natural state or after being changed into other foods like flour, bran, and a variety of other ingredients.

On the basis of keeping quality and suitability for storage, plant products can be grouped into durables and perishables. Cereals, pulses and oilseeds are mainly durables whereas fruits and vegetables are perishables. Perishables are high in moisture content and prone to spoilage after their harvest. Whereas cereals are low in moisture and could be stored for longer periods.

The plants products first stored and transported by man were all durables. It is only relatively recently that man has been able to keep and transport the more perishable products. Keeping quality of perishables varies from few hours to some weeks. The main difference between durables and perishables are summarized in Table 2.1.

Table 2.1: Difference between durables and perishables

Durables	Perishables
Designed for preservation	Not designed for preservation
Low moisture content, usually 10-15%	High moisture content, usually 50-90%
Small unit size	Large unit size, typically 5g to 6 kg
Often symmetrical in shape	Often asymmetrical in shape
Hard texture	Soft texture
Stable- inherent storage life of years	Perishable- natural storage life of a few days to month depending on type
Losses mainly caused by external factors, e.g. mould, insects and rodents	Losses caused by external factors, mainly moulds and bacteria, and internal factors, e.g. respiration, sprouting, ripening, etc.

i). Cereals

Food grain crops that belong to the grass family (Graminae) form a major part of the food grains basket. They yield seed grains usable as food by humans and livestock. The common cereals are: rice, wheat, barley, oats, maize (corn), sorghum, rye, and certain millets. Jowar and Bajra are important millet crops grown in India. There are several reasons why cereals are so important on the human diet. They can be grown in a variety of areas, some even in adverse soil and climatic conditions. They can be easily cultivated and give reasonably assured high yields compared to most other crops. Cereal grains are grown in greater quantities and provide more energy worldwide than any other type of crops. Because of their big contribution to the dietary and nutritional requirements, these are known as ‘staple foods’. In some developing nations, grains constitute practically almost the entire diet of poor people.

With an estimated yearly yield of 540–580 million metric tonnes, wheat is one of the most significant cereal crops in the world. The grass family Gramineae includes the genus Triticum, which is home to wheat. The two main wheat subgroups currently farmed for food purposes are common wheat (Triticum aestivum) and durum wheat (Triticum durum). The most valuable of all food grains, wheat is utilised extensively in all phases of processing, from whole to finely ground and sifted. The most crucial component in a bakery is wheat flour, which gives most bakery goods like breads, cakes, cookies, and pastries structure and weight. The two types of wheat are hard and soft. Compared to soft wheat, hard wheat has a higher protein content.

4.1. Structure and Composition of Cereals

A) Structure

The structure of all cereals is similar, yet each one has its distinguishing features. The cereal grain is a one-seeded indehiscent fruit or caryopsis. The basic structure involves three parts--the bran (a layered protective outer coat), endosperm (the large starchy part, containing some protein) and the germ (the embryonic part of the plant) (Fig. 2.1).

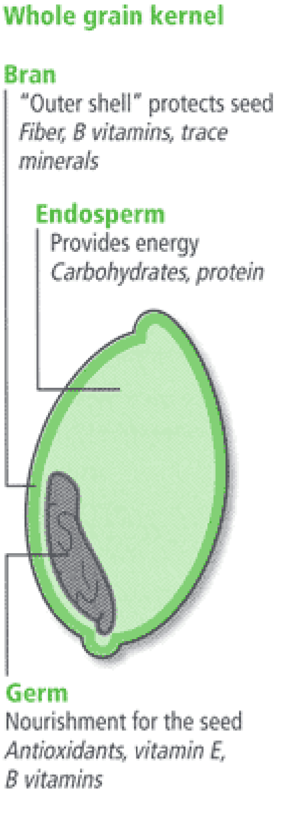


Fig. 2.1: Structure of cereal grain

The grains also have a husk cover which surrounds the entire bran. The husk or hull is the external, fibrous part of the grain that protects the grain during its formation and is totally indigestible. The bran consists of several layers, the fruit coat (pericrap) and seed coat (testa). The germ or embryo is the part of the grain from which a new plant develops. The endosperm or starchy part constitutes between 80 per cent and 90 per cent of the grain. It is the food store of the grain providing nourishment for the germinating plant. It is the most important part of the grain for the consumer and miller since it is from this part that the flour is obtained.

Important food substances like carbohydrates, protein, fat, vitamins and mineral matter and water/moisture are found in cereals. However, they occur in different quantities in the different grains. Some contain large quantities of protein while others practically have none. Certain ones have considerable fat content while others have it only in lesser quantities. A characteristic of all cereals, however, is that they contain a large amount of carbohydrate and a small amount of water/moisture.

B) Nutritional Composition

Cereal grains contain carbohydrates, fats, proteins and mineral matter.

i. **Carbohydrates:** We have already learnt in the Unit 1 the physiological functions of carbohydrates in human body. Carbohydrate in the form of starch is the major food substance found in cereals. Rice with 75 per cent starch content is the highest starch containing cereal while oats having less than 50 per cent starch has the least starch content. Distributed throughout the grain in tiny granules, starch is more easily digested than either protein or fat. However, starch in its natural form is insoluble, tasteless and unsuitable for human consumption. To make it digestible and acceptable it must be cooked or processed.

ii. **Fats:** The fat content provides the heat-and energy-producing qualities in cereals. Of the important cereals used as food, oats and corn contain the more amount of fat. The oil of corn, because of its lack of flavor, is frequently used in the manufacture of salad oil, cooking oil, and pastry fat. The fat that occurs in cereals becomes rancid if it is not carefully stored. In the making of white flour, the germ of the wheat is removed. And since most of the fat is taken out along with the germ, white flour keeps much better than the flour from which the germ is not abstracted in the milling process.

iii. **Proteins:** Cereals are essentially a carbohydrate food, but some also yield a good proportion of protein. Cereal proteins are however deficient in lysine and methionine. This is in contrast to the food from animals sources that yield mainly protein, with the exception of milk which yields carbohydrates also. The grain that contains the most protein is wheat and it occurs as gluten, a substance that is responsible for the gumminess and elasticity of the wheat flour when it is mixed with water. The rubbery consistency of bread dough is also because of gluten. Cereals that contain no gluten do not make good bread. Rye is only next to wheat in protein content. Rice contains the least. The protein sourced from cereals is relatively cheap compared to that from other food sources.

iv. **Minerals:** Cereals also contain a variety of minerals required for the human body. Much of the mineral matter lies directly under the coarse outside covering; some of it is lost when this covering is removed in the milling. For this reason, the grains that remain whole and the cereal products that contain the entire grain are much more valuable for nutritious reasons. In the diet/dish if sufficient mineral content is sourced from vegetables, fruits, and milk, it is perhaps unnecessary to insist on whole cereals. But if the diet is at all limited in variety, it is advisable to select the whole grain.

Cereals contain very little water/moisture in their composition. This is a distinct advantage, for it makes their nutritive value proportionately high and improves their keeping quality. This low proportion of water/moisture allows them to be stored easily without much chances of spoilage.

4.2. Wheat Processing

4.2.1. Milling

The objective of wheat milling is to grind cleaned and tempered wheat by separating the outer husk from the internal endosperm. Early processing of wheat was accomplished by means of hand grinding, grinding stones, or a mortar and pestle. Later on wheat was milled between two circular millstones, one fixed and the other mobile and rotating. Recent technology of wheat milling involves metal cylinders or rollers for milling purposes.

4.2.2. *Cleaning*

Wheat received at mill may contain certain impurities entering from field, during storage and transportation, or accidentally. Frequently encountered impurities include: straws, chaff, sticks, weed seeds, other cereal grains, shrunken and broken kernels, infected kernels, mud, dust, stones, metal objects, etc. Wheat cleaning operation makes use of certain characteristics of impurities which are different from those of wheat e.g. size (length and width), shape, terminal velocity in the air currents, specific gravity, magnetic and electrostatic properties, colour, surface roughness, etc.

The grain is initially passed through a series of screens of selected apertures that removes matter either smaller or larger in size than the wheat kernel. Gross foreign material is removed over a set of sieves (rubble separator).

In gravity separator, impurities which are similar to wheat in size but different in specific gravity are separated out. Wheat grains are then moved on tilted screen, through which adjusted air currents are drawn. Heavier materials such as stones are separated and remain closer to screen, while lighter impurities and wheat floats down the screen.

After gravity separation, series of rotating discs separators remove impurities that are similar in diameter but different in shape from the wheat. This rotating discs with indentations pick-up only those wheat kernels that fit into the pockets and allow other grains such as oats, barley to pass through.

Dry scouring of wheat kernel removes any dirt adhering to it. In the scorer wheat kernel is bounced against a wall, which may be of a perforated sheet metal, a steel wire woven screen or any emery surface.

Magnetic separators separate foreign materials such as nails, pieces of metal that could damage equipments or generate spark, which could cause a dust explosion.

In final cleaning operation, wheat is washed by water. Wheat is immersed in water (0.5 - 1.0 lit per kg) and then conveyed by means of a worm to a centrifugal machine called whizzer, where it is vigorously agitated and spun dried. Washing of wheat removes crease dust.

4.2.3. *Conditioning / Tempering*

Conditioning of wheat is carried out primarily to improve the physical state of grain for milling. In conditioning moisture content of wheat kernel is adjusted. This includes heating and cooling of the grain for definite period of time, in order to obtain the desired moisture content and distribution. At this adjusted moisture level of wheat before milling, wheat endosperm becomes mellow and bran becomes tough. Bran that absorbs proper amount of moisture becomes elastic and will not splinter during grinding to contaminate the flour with fine particles, and thus flour becomes whiter in colour. The endosperm becomes mellower and more friable, thereby reducing the amount of power required to grind it.

Several methods are employed to condition the wheat. Heating the wheat, application of warm water, application of live steam, or just intensive mixing of wheat and water are some of the methods used to increase the amount and rate of water penetration into kernel.

Three factors affect the rate and level of water penetration into the kernel: temperature, amount of water (% moisture content) and time. The ideal water and wheat temperature for tempering condition is 25-C. Higher temperature will increase the rate of penetration into the kernel. Temperature above 50^0C will change endosperm starch and protein characteristics.

Typical moisture contents of tempered wheat and tempering times are as follow:

Table 4.1 Typical moisture contents of tempered wheat and tempering times

Type of wheat	**Optimum moisture content of tempered wheat**	**Tempering time (Hrs)**
Hard spring wheat	16 - 17%	36
Hard red winter wheat	15.5 - 16.5%	24
Soft wheat	14.5 - 15.5%	10
Durum wheat	16 - 17.5%	6

4.2.4. *Milling / Separation of flour*

Wheat flour milling is a process that consists of controlled breaking, reduction and separation, Wheat flour milling involves three basic processes:

i). Grinding: Fragmenting the grain or its parts
ii). Sieving: Classifying mixtures of particles based on its particle size
iii). Purifying: Separating bran from endosperm particles based on their terminal velocity, by means of air currents.

Grinding of the wheat occurs between two cast rolls (break rolls) that rotates against each other. These rollers are fluted and they are not in contact with each other. The upper roller rotates two and a half time for each rotation of the lower one. Hence, the grain is engaged between fluted serrations of the rolls and broken or cut by the faster roll as it is held back by the slower roll. This initial stage in milling process is referred as breaks. The breaks are used in the grinding steps to separate the bran, germ and endosperm from each other. The grist coming out from the rolls is sifted through a plansifters. The plansifter is a machine consisting of a vertical nest of horizontal sieves, the whole assembly gyrating in a horizontal plane. A single plansifter consist of four or five different mesh sizes may yield five or six fractions of different particle size.

The series of break rolls and sieves converts the grain into semolina, which is small granule made up of endosperm. The outer husk is collected separately as bran. The semolina is separated into three grades: fine, medium, coarse in an operation called ‘gradual reduction system’. Here the rolls are smooth and one rotates only one and a quarter times for each rotation of the other.

These three streams are then put through purifiers. Purifier consists of a long, narrow, sieve set. The sieves become coarser progressively in size of mesh from head to tail. The sieve section is connected to a fan and the air is drawn up through each sieve section to draw off branny particles.

The number of parts of flour by weight produced per 100 parts of wheat milled is known as the flour yield, or percentage extraction rate. The wheat grain contains 82% of white starchy endosperm, but it is never possible to separate it out fully from the bran. Extraction rates of different flours are as follow:

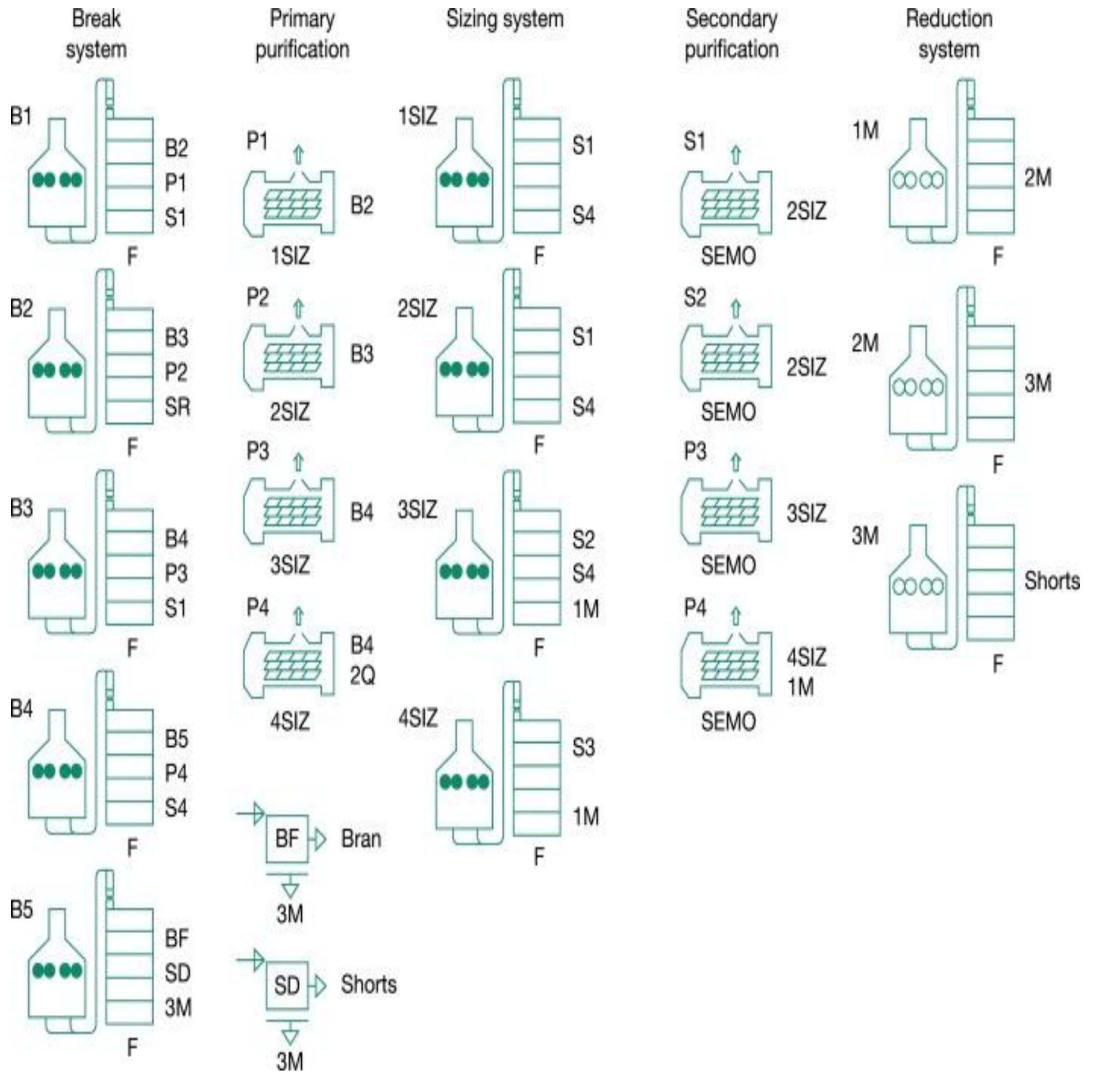
Table 4.2 Extraction rates of different flours

Sr. No.	Flour	Extraction rate (%)
1	Wholemeal flour	95
2	Brownish flour	85
3	Creamy flour	80
4	White flour	70

4.2.5. MILLING OF DURUM WHEAT/ SEMOLINA

Because evenly shaped semolina is the desired product for fine pasta and couscous, durum wheat mill flows differ from ordinary wheat mill flows. Lower value durum wheat flour is unavoidably produced as a by-product of semolina milling. The diagram depicts a typical durum wheat semolina mill flow.

Figure 4.2.1.



In contrast to hexaploid common or bread wheat (Triticum aestivum), durum wheat is a tetraploid species of wheat (Triticum turgidum spp. durum). Due to the extreme hardness of durum wheat, a high semolina production is possible. The break mechanism for durum wheat is expanded to permit gradual kernel breaking in order to achieve maximum semolina output and minimal flour production. Repeated sizing, grading, and purifying processes result in evenly sized, free of sticking bran semolina from the break system. Due to the fact that sizing purifiers produce the majority of semolina, durum mills can be easily identified by their numerous purifiers. When compared to the semolina used by contemporary pasta makers, which tends to be finer, traditional durum wheat semolina is coarser.

Semolina is created by extruding stiff dough (made of semolina combined with warm water) through dies of different shapes after it breaks into reasonably homogenous, big fragments during milling. Semolina is used to make a variety of high-quality pasta products. A light amber hue and minimum criteria of 12.5% protein, Hagberg 200, 70% vitreous grains, 76 kg/hl specific weight, less than 2% contaminants, and free of mould are required for this high grade market (up to a 50% premium).

The crucial steps in the milling process that are required to produce high-quality final products as follows:

1) Grain Reception: The mill receives the high-quality grains for further grinding.

2) Cleaning: To eliminate as many pollutants as possible after receiving, it must be thoroughly cleaned; some of these impurities are picked up in grain handling systems.

3) Tempering: Following cleaning, water is added and the wheat is left to sit in bins for eight hours. This makes it simple to separate endosperm from bran. The inner, semolina- and flour-containing portion of the wheat kernel is called endosperm. The wheat kernel's outermost covering is called bran. Bran is made sufficiently robust through tempering so as to prevent excessive fragmentation. After that, the wheat goes through a debranning procedure that eliminates some of the endosperm's bran.

4) Milling: The wheat is subsequently taken there. To create semolina with the right clarity and particle size, the mill uses a complex system of light grinding, sifting, and purifying. It moves past some corrugated coils.

5) Handling of final goods: Rolls are configured to release large endosperm chunks and little flour because durum is crushed into coarse semolina bits for pasta. It is then pneumatically raised to the mill's top and dropped through the sifters. The result is divided into four or five streams as it passes through the sieve, depending on its size. These streams can either go to the purifier, another roller mill for more grinding, or a flour bin.

6) Finished product quality, specifications, and applications: Semolina will be produced as a finished good after milling and purification. The purifier is a device that has two portions, each of which has layers of oscillating sieves. These sieve layers are supported by a metal frame. With a modest downward slope from the machine's front to its back, the frame is hanging. Lighter branny materials float to the tail end where they are discharged to feed or additional grinding while larger endosperm particles fall through the stock layers as a result of controlled air currents being drawn through the material flow. If the endosperm particles are the right size, they are next converted to semolina; otherwise, they are ground even finer in a roller mill.

The process of grinding, sifting, and purifying is performed numerous times to extract as much semolina as is possible. Semolina is blended from various purifier streams of various granulations that must fulfil customer requirements. It then goes through rebolt sifters, scales, and, if necessary, vitamin enrichment.

4.2.6. TECHNOLOGY OF PASTA PRODUCTS

4.2.6.1.Introduction

A broad category of foods collectively referred to as spaghetti, macaroni, vermicelli, and noodles is referred to as "pasta." The greatest pasta user in the world is Italy, which is often thought of as the origin of pasta goods. Given that they are manufactured with food-grade dough formed from wheat semolina or flour and water, these items are known as Pasta alimentari (alimentary paste) in Italy. The term "pasta products" refers to a group of foods that are each made by drying formed units of dough made from semolina, durum flour, farina, or any combination of two or more of these ingredients with water, with or without one or more optional ingredients like egg white solids, quick cooking agents, seasonings, etc.

In India, pasta products are referred to as macaroni items. According to the FSSA (Food Standards Safety Act), macaroni products are made from maida or suji and may or may not be supplemented with ingredients such as milk powder, spices, vitamins, and minerals. While additional components like gluten, casein, and vegetables are also allowed to be included to macaroni products, according to BIS (Bureau of Indian Standards).

4.2.6.2. Raw Materials for Pasta Products

4.2.6.3. Durum wheat

The preferred raw material for making pasta products is durum wheat (Triticum durum). Only 4.5% of the world's wheat is produced from durum wheat, which is grown on around 8.8% of the total land utilised for growing wheat. The toughest type of wheat is called durum, which is a tetraploid species. When choosing wheat, durum millers typically favour the following physicochemical traits.

Table 14.1 Physico chemical characteristics of durum wheat

Characteristic	Value
Test weight (kg/hl)	82
Vitreous kernels (%)	77 � 96
1000 kernel weight (g)	30 � 55
Moisture (%)	10.5 � 12.5
Protein (%)	14 � 14.5

4.2.6.4. Semolina

Semolina, durum granule, and durum flour are the three primary milling products of durum wheat that are used to make pasta products. It is too difficult to mill durum wheat into fine flour. Durum wheat is first washed to get rid of foreign objects, cracked, and shrunken kernels. The seed coat is then toughened (conditioned) to a moisture level of around 16.5% so that bran and endosperm may be separated effectively. To open up and scrape the wheat kernels and separate the endosperm from the bran, the tempered wheat is ground on a series of corrugated break rolls. The middlings (semolina) are ground to the required size using a second set of reduction rolls with finer corrugation.

In order to effectively reduce the endosperm to the desired granular size, different vibrating sieves are used in between grinding stages. The last stage of milling entails purifying to separate as much flour and small bran particles from the semolina as possible. A commercial durum wheat mill will convert good quality durum wheat into 64% semolina and 9% flour. Semolina with more consistent particle size is desirable since it is easier to combine with water to create homogenous dough for extrusion.

For making pasta, semolina particles should be no larger than 150. Granular durum is typically used to make quick pasta shapes like elbows or shells.

4.2.6.5. Water

Pure, flavourless, and potable water should be used to make pasta products. The bacterial count of the water and the bacterial count of the completed product are directly correlated since pasta can be cooked below pasteurisation temperature.

4.2.6.6. Pasta Processing

Up until around 1800 AD, all pasta products were manufactured at home. The first manually operated mechanical press appeared around the year 1850. Equipment like mixers, kneaders, hydraulic extrusion presses, and drying cabinets became accessible at the start of the 20th century. Pasta extrusion and drying technology has advanced to the point that different-sized and -shaped pasta of up to 7000 kg may now be made continuously in an hour.

The continuous press, shaker/spreader, pre-dryer, finish dryer, storage, and packaging are typical processing steps for pasta.

4.2.6.7. Extrusion

Semolina and water are metered in the continuous press at a predetermined ratio to create consistent dough. Excellent pasta is produced when the dough moisture level is between 30 and 31%. In a counter-rotating mixing chamber, water and semolina are uniformly blended. Dough balling is avoided by the mixing shaft turning anticlockwise. Some mixing chambers are vacuum-operated to prevent the emergence of tiny air bubbles in the dough and to slow the oxidation of the xanthophyl/lutein colours. Otherwise, pigment oxidation lessens the pasta's appealing yellow look and, as a result, its customer acceptability. Pasta's mechanical strength is decreased and it appears chalky when there are air bubbles present.

Before being extruded via a die, the hydrated semolina is fed through an extrusion auger in the extrusion chamber, which homogenises and cohesively forms the dough into a plastic mass. As a result of the significant heat generated by friction during extrusion, extrusion barrels are typically fitted with water-cooled jackets to keep the temperature of the pasta between 40 and 45 C throughout the process.

With the use of several dies and cutter knives, different sizes and forms of pasta can be produced. Teflon inlays are typically utilised with bronze or stainless steel dies. Teflon inserts increase the pasta's surface quality and prolong the life of the die.

4.2.6.8. Drying

Drying is most critical step in pasta processing. Pasta is dried from around 30-31% w/w moisture to 10-12% w/w moisture during drying process. Uniform drying of pasta is necessary to prevent moisture gradient. Uneven drying causes stresses, which can cause the product to crack or check (i.e. ruined by tiny hairline cracks). Checking can occur either during drying cycle or during storage.

The most important phase in the preparation of pasta is drying. During the drying process, pasta is dried from 30–31% weight-weight moisture to 10-12% weight-weight moisture. To avoid moisture gradient, pasta must be dried evenly. Stresses brought on by uneven drying might result in the product checking or cracking (i.e., being destroyed by minute hairline cracks). Either during the drying process or during storage, checking can take place.

A variety of commercially available dryers are used for drying. They fall into two categories. They either use high- or low-temperature techniques. For low temperature drying of pasta, the drying times for long items are roughly 16 hours and for short items are roughly 8 hours. Shorter drying periods (10 hours for long goods, 4.5 hours for short goods) and enhanced product and bacterial quality were the results of high temperature drying, which boosted the drying temperature from 55 C to 75 C.

With the advancement of technology, drying temperatures for pasta have gone from 75 C to 100 C and above. The benefits of this very high/ultra high temperature drying include significant time savings (5.5 hours for long items, 2.5 hours for short items), increased product quality, and

The drying of pasta using microwave technology and traditional hot air pre-dryers has proven a success. Microwave drying has a number of benefits, including the need for less floor space (about 1/3 to 1/4 of that of a traditional dryer), drying times that are shorter (about 2 hours), increased product colour and cooking quality, a decrease in the number of pests, improved cleanliness, and lower operating costs.

4.2.6.9. Packaging

The packets in which pasta products are offered come in a wide variety of sizes, shapes, and designs. The primary factors in selecting packaging materials are: keeping the product free from contamination, using sufficiently gentle mechanical handling to ensure minimal product breakage during shipment and storage, using a high degree of accuracy and precision in the weighing and filling of the packages, and presenting the product favourably with consumer appeal.

For the packaging of pasta products, flexible films such as cellophane, low-density polythene bags, and others are frequently utilised. In addition to this packaging, pasta is wrapped in cardboard boxes because they are convenient to stack, offer good physical protection for the product, and make it simpler to print advertisements than on plastic films.

4.2.7. Fractionation of flour

As a result of harsh processing conditions that devitalize the gluten, fractionation of entire kernels frequently results in poor gluten synthesis. Additionally, due to the strong propensity of gluten proteins to aggregate, the wet-milling method used to directly remove starch and gluten from wheat kernels is hampered.

As a result of harsh processing conditions that devitalize the gluten, fractionation of entire kernels frequently results in poor gluten synthesis. Additionally, the high tendency of gluten proteins to clump together prevents the wet-milling method for directly separating starch and gluten from wheat kernels.

4.2.7.1. Whole wheat wet fractionation process

When opposed to making starch from the whole kernel, making starch from flour has two significant drawbacks. First off, only 75–80% of the starch originally present in the wheat is extracted during the milling process, leaving 85–90% of it available for starch synthesis.

Second, the dry milling procedure degrades some of the starch. Damaged starch can make it difficult to use starch for some purposes and decrease prime starch yields.

4.2.7.2. Drying of gluten

The gluten quality is mostly determined by the last drying step. Due to endogenous or exogenous proteolytic action, gluten degrades quickly when stored in a wet state, becoming highly soft and extensible and unsuitable for the majority of major uses that depend on the preservation of the distinct cohesive, viscoelastic qualities. Due to its sensitivity to drying, the manufacturing of dried essential gluten on an industrial scale involves numerous challenges.

4.2.8. BREAD MAKING PROCESS

4.2.8.1. Introduction

One of humanity's most significant discoveries is the ability to make bread. Baking dough with wheat flour, water, yeast, and salt as its key ingredients produces bread. Other flours from different grains, milk and milk products, fruits, gluten, and other components may also be included. When these components are combined in the right amounts, two processes start: Gluten is created when (i) the protein in flour starts to hydrate and form a cohesive mass, and (ii) carbon dioxide gas is produced when yeast enzymes react with carbohydrates. The development of a gluten network, aeration of the mixture by gas inclusion, and coagulation of the substance by heating it in the oven are the three essential needs for manufacturing bread from wheat flour.

4.2.8.2. Principle of Bread Baking

When baking bread, three technological principles come into play:

1) **Starch conversion**: Wheat flour starch is partially transformed into sugar, which yeast uses during fermentation to produce alcohol while simultaneously releasing CO2 gas, which gives baked bread its porous, open honeycomb texture.

2) **Mechanical stretching**: When wheat protein is hydrated, it creates gluten fibres. These fibres are mechanically stretched to create a fine, silky texture. Even once the protein is denatured during baking, this configuration is irreversible. The production of CO2 gas during yeast fermentation and mechanical mixing are both used to stretch the gluten to some extent.

3) **Flavour development**: The alcohol and other substances produced during yeast fermentation, along with flavour substances created during baking, are what give bread its distinctive flavour.

4.2.8.3. Ingredients and their Functions in Bread Making

4.2.8.4. Essential ingredients

4.2.8.4.1. Flour

Flour The composition of dough, and consequently the structure of bread, depends on flour. The main functional protein in wheat flour is gluten (also known as gliadin and glutenin). If gluten is hydrated and mechanically processed, it will create a fibrillar framework. Thus, dough that is cohesive, elastic, and extensible is created from wheat flour. This three-dimensional viscoelastic gluten network preserves gas created by sugar fermentation and adds to the structure of bread and dough.

When baking, starch plays a crucial part in the dough. Gas cells enlarge, gluten networks stretch, starch granules absorb water, and partially gelatinize when heat is applied. After baking, this thick mixture hardens to form a gel. Bread flour should have a satisfactory protein concentration of 11–13% and a moisture content of no more than 14%.

4.2.8.4.2 Water

Flour Flour is essential to the construction of bread and the composition of dough. Gluten, sometimes referred to as gliadin and glutenin, is the primary functional protein found in wheat flour. Gluten will produce a fibrillar framework if it is hydrated and mechanically treated. So, wheat flour is used to make extensible, elastic, cohesive dough. The structure of bread and dough is improved by the three-dimensional viscoelastic gluten network, which also stores gas produced during sugar fermentation.

Starch is a key component of the dough in baking. When heat is applied, gas cells expand, gluten networks widen, starch granules absorb water, and partially gelatinize. This viscous liquid hardens to produce a gel after baking. Bread flour needs to be wet and have a suitable protein percentage of 11–13%.

The ideal bread flour should have a moisture percentage of no more than 14% and an acceptable protein concentration of 11–13%.

4.2.8.4.3 Yeast

Yeast ferments fermentable carbohydrates to create carbon dioxide and ethanol. Additionally, it aids in the development of flavour precursors during fermentation. Temperature, nutrient availability, water, pH, sugar concentration, salt, level, and kind of yeast all affect how quickly dough ferments. Compressed yeast and dried yeast are the two types of yeast that are typically used in baking. Saccharomyces cerevisiae live cells make up both types.

. *4.2.8.4.4 Salt*

Salt improves flavour and aids in regulating yeast fermentation. The gluten is also made tougher, and the dough becomes less sticky.

4.2.8.5. Optional ingredients

The optional ingredients used in bread formulation are listed in Table 11.1 along with their functions.

Table 11.1 Functions of optional ingredients in the bread

S.N.	Ingredient	Example	Function
1.	**Mineral yeast food**		Controls fermentation
i.	Water conditioner (Calcium salts)	Calcium acid phosphate Calcium sulfate	

		Calcium peroxide	
ii.	Yeast conditioners (Ammonium salts)	Ammonium chloride Ammonium phosphate Ammonium sulfate	
iii.	Dough conditioners (Oxidizing agents)	Potassium bromate Dehydro ascorbic acid Potassium iodate Dicalcium phosphate	
2.	**Sugar**	Sucrose High fructose corn syrup	Energy source for yeast Fermentable carbohydrate Flavour, Sweetness and flavour compounds generated during fermentation and baking Crust colour: Caramelization and non enzymatic browning Delays staling of bread by increasing hygroscopicity and thus tenderizing the crumb
3.	**Shortening**	Edible fats and oils containing dough conditioners and emulsifiers (Calcium stearoyl-2-lactylate, sodium stearoyl-2-lactylate, Mono and diglycerides, Polysorbate 60, Succinylated monoglycerides, Ethoxylated monoglycerides, Sucrose esters)	Facilitates dough handling and processing Eases gas cell expansion in dough Increases loaf volume Improves crumb grain uniformity and tenderness Lubricates slicing blades during slicing Extends shelf-life

4.	**Dairy products**	Skim milk powder Sweet cream butter milk Sweet dairy whey Caseinate Whey protein concentrate	Nutrition: high in lysine and calcium Flavour enhancement Improves crust colour (Maillard browning) Buffering effect in dough and liquid ferments
5.	**Mold inhibitors**	Sodium propionate Calcium propionate Sodium diacetate Potassium sorbate Vinegar	Retardation of spoilage due to mold growth Retards formation of rope by *B. subtilis*
6.	**Wheat gluten**	Wheat gluten	Enhances dough strength Increases water absorption Increases bread loaf volume Imparts greater stability to the dough during fermentation
7.	**Malt**	Malt flour Malt extract Dehydrated malt extract	Contributes fermentable sugar (maltose) Enhances flavour Contains amylases, which converts starch to sugar Improves crust colour Extends shelf-life because of improved water absorption
8.	**Enzyme supplements**		

i.	Amylases	Cereal amylase: barley malt Fungal amylase: *Aspergillus oryzae* Bacterial amylase: *B. subtilis*	Convert starch to sugar Aid crust colour Improve dough handling Extend shelf-life
ii.	Protease	Fungal protease: *Aspergillus spp.* Bacterial protease: *B. subtilis* Bromelain (Fruit)	Weaken dough due to cleavage of peptide bonds in wheat protein Reduce dough mixing time Increase pan flow
iii.	Lipoxygenase	Soya	Whiter bread crumb Improves shelf-life Increases dough strength and mixing dough tolerance

4.2.8.6. Bread Manufacturing

The dough is created, then cut into pieces that are the right size. In the intermediate proofer, where the coarsely stretched gluten fibre have time to regain their flexibility, the divided dough is rolled into a ball and then used. This allows the surface skin to be formed without breaking. The dough is passed after intermediate proofing.The dough is run through a series of pairs of rollers to create a sheet after intermediate proofing. The dough is now sheeted and run through a pressure board to form a cylinder.The pieces of dough that have been formed are then put into individually buttered bread baking tins. The last prover is then used to pass the panned dough pieces under temperature and humidity control. The dough trays are moved to the baking oven when they have finished proving completely. The loaves are de-panned after baking, chilled, and then cut into slices.

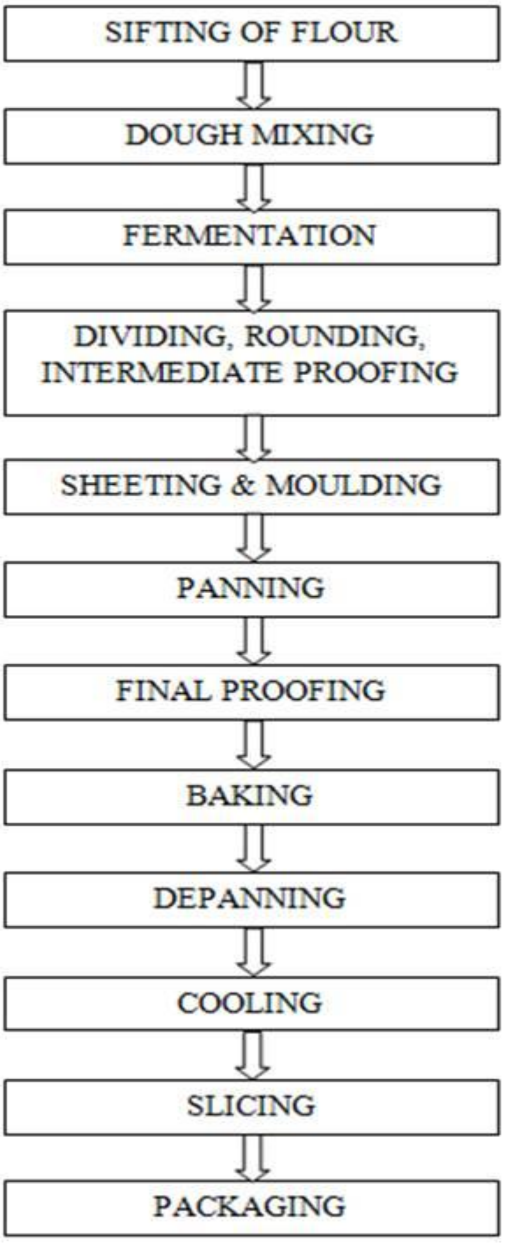


Fig.1 Flow diagram for bread manufacture

4.2.8.7. Methods of Bread Making

Different techniques for creating bread can be broadly categorised into three categories based on how the dough is made: conventional (bulk fermentation) dough development methods, mechanical dough development methods, and chemical dough development methods.

The sponge and dough method, liquid fermentation method, straight dough method, no-time dough method, frozen dough method, continuous bread manufacturing process, and Chorleywood bread process are the main production techniques used in wholesale bread manufacture.

4.2.8.7.1. Sponge and dough process

This is the way that businesses most frequently utilise to make bread. Flour, water, and yeast are combined to make sponge, which is then given time to ferment. The sponge is then added along with the proper amount of water, flour, and other ingredients. The sponge to dough ratio is kept at 70:30. The dough is thoroughly mixed and then left to ferment for three to five hours at 30 C. To produce bread loaves of the proper weights, the dough is next separated into pieces. The dough is then divided into spherical pieces, given a 7-minute rest period, and then sheeted, shaped, and panned. 55 minutes are spent proving the dough at 42 C and 85% relative humidity (RH). The bread loaves are then baked at 230 C for 18–20 minutes, cooled, and then cut into slices and wrapped.

4.2.8.7.2. Liquid fermentation process

This technique uses a liquid instead of a plastic sponge, but its basic principles are the same as those of the sponge and dough technique.

4.2.8.7.3. Straight dough method

At the mixer, all of the formula ingredients are combined in one motion. After being fully incorporated with gluten, the dough is fermented. Following that, the fully fermented dough is handled using the sponge and dough process. Retailers or bakeries for speciality breads employ this method.

4.2.8.7.4. No-time dough process

The only difference between this method and the straight dough method is that mixing is done primarily mechanically with the use of powerful mixers. The addition of other components, such as L cysteine, yeast meals, and proteolytic enzymes, improves this mixing process further. Short or no fermentation is provided to the combined dough before it is divided, rounded, moulded, proofed, and baked. The production of frozen dough and retail bakeries are good candidates for this technique.

4.2.8.7.5. Frozen dough method

In-store bakeries use frozen doughs for baking. The typical method used to create frozen doughs is the straight dough method. Using rapid freezers, the dough units are instantly frozen to a core temperature of 7 C, then kept at 15 C. In in-store bakeries, the dough is placed in a retarder at 1°C, proofed for 75–90 minutes at 32°C, and then baked. About 8 to 12 weeks are anticipated for frozen dough's shelf life.

4.2.8.7.6. Chorleywood process

The world over, this method is extensively employed. Its roots are in the United Kingdom. The fundamental idea is a closed, high-speed mixer with blades specially designed for mixers. The mixing is often done in a vacuum. Tweedy and Stephan mixers are the two most popular types. Azolobicarbonamide (ADA) and ascorbic acid are the oxidants employed in this procedure.

4.2.8.7.7. Staling of Bread

During storage, bakery products go through physical-chemical, sensory, and microbiological changes. Staling is the general name for this. Staling refers to a sequence of modifications other than those brought on by microorganisms that cause deterioration that lower customer approval. Bread that has aged typically loses its crispness in the crust and develops a firmer crumb. Loss of flavour and the appearance of stale flavour are additional linked alterations. Moisture migration from the crumb to the crust is the fundamental reason why bread stales. Unknown as of yet is the full process of bread staleness. However, the Schoch and French explanation is the one that is generally recognised. This hypothesis states that the primary cause of staling is retrogradation of starch.

During baking, starch gelatinizes and amylose is leached off. The amylose component crystallises upon cooling and gives the bread solidity, which is a sign of the bread's freshness. The bread firms up as a result of amylopectin retrogradation, which takes place slowly during storage. Due to the ability of retrograded amylopectin to return to its amorphous state, which lessens stiffness, this process is heat-reversible. The starch granule depicted in Fig. 11.3 has undergone physical and chemical modifications, which Zobel and Kulp have detailed.

4.2.8.7.8. Ropy Bread

If the bread dough is contaminated with B. mesentericus, it will become ropy. Baking does not render the bacteria's spores inert. Within one to three days of baking, a sticky, gummy substance that may be twisted into threads forms in the heart of the bread. The bread also starts to taste strange.

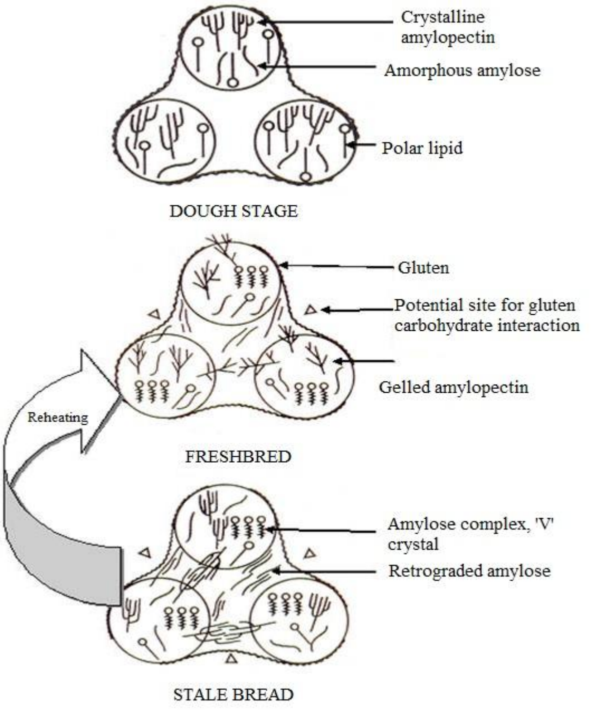


Fig.3. Mechanism of bread staling

4.2.9.Biscuits Making Process

4.2.9.1. Product Characteristics

A low moisture bread product is the biscuit. Biscuits often contain less than 4% moisture, depending on their weight, thickness, and shape. Soft wheat flour combined with a lot of sugar (25–55%) and shortening (20–60%) can be used to make biscuit dough. They are divided into different categories based on how the dough is applied to the baking band, such as rotary moulding, wire-cutting, cutting machines, etc.

4.2.9.2. Ingredients

4.2.9.2.1. Flour

The primary ingredient in most recipes is soft wheat flour. 65–75% of wheat flour is made up of carbohydrate, and 7–16% of it is protein. During the process of making dough, when water is introduced, starch absorbs a sizable amount of water and may serve as filler in the continuous protein network with the proteins. Granules of starch, which make up a significant portion of the dough, gelatinize during baking. The flour used for cookies and crackers is often not treated with additives. Soft wheat flour with a protein concentration of 8 to 10% and less than 0.4% ash is suitable for making premium-quality cookies.

4.2.9.2. Water

The textural qualities of baked goods are influenced by water. Water serves as a plasticizer, and the quantity is changed to create a batter or dough that is suitable for processing. Water serves as a key heat transmission medium during baking by evaporating and condensing to hydrate proteins, gelatinize starch, activate enzymes, make leavening agents operate, dissolve sugar and salt, and hydrate and activate proteins.

4.2.9.3.Fat

Fat gives items a shortness quality that gives them a soft, enjoyable, and crumbly texture. Dough and batters, surface sprays, cream fillings, and coatings like chocolate all need fats and oils. Emulsifiers are frequently used in conjunction with or premixed with bakery fats. Emulsifiers work to encourage the development and stabilisation of water, fat, and air emulsions.

4.2.9.4.Sugar

After flour, sugar is the second-most significant ingredient in soft wheat products such biscuits, cookies, cakes, etc. Sweeteners serve the following purposes in addition to making the food sweeter: tenderising, texture, yeast nutrition and fermentation management, stabilising, bulking agent, humactancy, flavour, crust colour, and shelf-life extension. Utilised sweeteners include sucrose, corn syrup solids, invert sugar, honey, glucose syrup, and a few authorised strong sweeteners.In the production of soft wheat goods, sucrose, corn syrup solids, invert sugar, honey, glucose syrup, and a few other approved powerful sweeteners are utilised.

4.2.9.5.Salt

Salt is added to dough as a seasoning or as flavour enhancer. Salt also inhibits yeast growth and thus help in controlling the fermentation.

4.2.9.6. Other ingredients

- In addition to these ingredients, biscuits can also be made with leavening agents, emulsifiers, chocolate, dairy products, egg products, fat substitutes, spices, tastes, and colours.

a**). Baking powder:** is frequently used to leaven the dough for cookies and biscuits. It regulates the spread and gives the product a lightness. Utilising baking soda (sodium bicarbonate) more frequently than is advised could give the finished product an alkaline flavour. Ammonium bicarbonate should be utilised in items that are quite dry after baking; otherwise, if the product is damp, ammonium scent will be maintained. Sodium bicarbonate and an acid salt are combined to make baking soda. Gas will develop during baking if there is moisture present, aiding in the leavening of the finished product.

There are three types of baking powder:

1. Quick-acting: Baking releases very little gas, while bench operations release the majority of the CO2.

2. Slow-acting: Baking causes all the gas to be released.

3. Double acting: Bakers use this baking powder the most frequently. This particular brand of baking soda releases some gas while being used on a work surface and some gas while being baked.

b). Milk Solids: Proteins in flour are bonded together by milk solids. Large amounts of milk solids result in less spreading of the cookies and biscuits.

c). Eggs: If eggs are included, they provide structure and enhance flavour and taste. It may cause biscuits and cookies to rise rather than spread if used in big quantities. Compared to entire eggs, egg yolks yield more soft cookies.

i. The technique for creating dough and dough pieces are:

- Dough Development
- Laminate
- Cut
- Moulded
- Extrusion
- Cut and co-extruded wire

ii. On the basis of hardness and texture

- Breaded pastries
- Cookies
- Crackers

The principal procedures in producing biscuits include (Fig..3)

1. **Mixing and kneading:** Weighed amount of sifted flour, sugar, shortening and flavouring agents are mixed in mechanical mixer. Water and baking powder are added during mixing to obtain dough of desired consistency. Kneading for 10-20 min produces biscuits with fine structure, smooth crust and better appearance.
2. **Sheeting and shaping**: The dough is then rolled into sheets of desired thickness by passing it through pairs of rolls. The sheets are then cut by mechanically worked stamped dividers fitted with dies.

3. **Baking and cooling:** the cut biscuits are then transferred to plate sheet or wire mesh bands travelling through ovens. The biscuits are generally baked at 450^{0}F for 15 min and cooled to ambient temperature after baking.
4. **Packaging:** the biscuits should be packed in moisture and grease proof cellophane or metalized laminated foils.

Fig. .3 Steps in involved in biscuit making

4.2.10. TECHNOLOGY OF CAKE MAKING

4.2.10.1. Product Characteristics

A batter is created from wheat flour that is soft or weak to make cakes. The traditional focal point of festivities and happy celebrations is cake. Cakes typically contain more sugar and shortening. Cake is a sophisticated emulsion and foam system that contains a significant amount of air as a tiny bubble in the batter.

Cakes are items that are primarily leavened by baking powder, occasionally by the inclusion of air, and sporadically by yeast. Cakes can be split into two groups, although being hard to define.

First, cakes with a higher fat content whose composition depends on the formation of a fat-liquid emulsion during batter mixing (such as fruit slab, Dundee, and ginger cake). These cakes are distinguished by having a high sugar content in the recipe, which allows starch to gelatinize during baking.

When baked, cakes set, producing a light product. Second, those with less fat (un-shortened cake), or even none at all, but a high egg content, which during mixing can aerate to a foam and imparts a distinctively spongy texture to products like angel food cake and Victoria sponge.

4.2.10.2. Ingredients

Essential components include flour, sugar, shortening, and eggs or skim milk powder. Baking powder, milk, fruit, and flavourings are required components, but not baking powder.

- Flour: It gives a cake its structure and keeps the other components distributed uniformly throughout the cake. Protein level in cake flour should be between 7 and 9%. Cakes are best produced using short patent flour, which has a fine granular structure and is made from soft wheat. To brighten the colour, cake flour is bleached more than other flours. The ability of starch to produce gluten is also altered by bleaching (starch gelatinizes more quickly).

- Sucrose is the sweetening ingredient most frequently used in baking cakes. Cakes with finely granulated sugar have an equal grain and a delicate feel. The tenderising effect of sugar on the proteins in the flour gives the cake its tenderness. Cakes' shelf life is extended and moisture is retained. The caramelization of sugar gives cake its golden crust colour.
- Cake shortenings should have effective creaming and emulsifying capabilities. By retaining the air cells added during the creaming process, fats have a tenderising effect on the proteins in the flour, making the cake tender. Additionally, it serves as a moisture retentive agent, keeping the cake moist and extending the shelf life of cakes. Cake-making fat should have a plastic consistency that can incorporate and hold tiny air cells during the creaming process.

- Egg; Flour and eggs provide the framework needed to support the cake's construction. The cakes receive moisture from eggs. The egg yolk's lecithin serves as an emulsifier and later intensifies the hue. Egg enhances nutritional value, taste, and flavour.
- Milk: The cake gets richness and structure from the milk. The binding activity of milk proteins on the protein in flour gives cakes their firmness. Lactose from milk sugar enhances the flavour, colour, and ability of the crust to retain moisture. The nutritional value is also increased by milk solids.

- Water: The presence of water is necessary for the production of gluten, the release of CO_2 gas from baking powder and the development of vapour pressure. Water controls the batter's consistency, which impacts the cakes' volume and texture.
- Salt: Other components used to make cakes have natural flavours that are enhanced by salt. By reducing the temperature at which sugar begins to caramelise, it also regulates the coloration of the crust. It can be used anywhere from 0.7% and 1.2%, depending on the flavour.
- Baking Powder: Different kinds of baking powder, when heated and wet with water, release CO_2 gas that expands during baking and gives cakes volume.
- Flavourings: Cocoa, chocolate, vanilla etc are added as flavours.

4.2.10.3. Cake Making Methods

4.2.10.3.1. Sugar batter method

Using this technique, sugar is gradually added after creaming the fat. Flour and raising agents are included with the mixture after it has been sufficiently aerated. To prevent the development of gluten, mixing should be kept to a minimum. Remaining liquid is added to the batter to get the proper consistency after all the flour has been combined.

4.2.10.3.2. Flour batter method

This procedure involves creaming together fat and an amount of flour that does not exceed the weight of the fat. Whipping sugar and eggs together creates a frothy froth. Once the remaining sugar has been dissolved in milk or water, the combination is added. The remaining flour and baking powder are then added and gently combined.

4.2.10.3.3. Blending method

This is applied to recipes where the amount of sugar exceeds the amount of flour. All components are combined, with the exception of milk and sugar. To create a smooth batter, the previously mixed ingredients of sugar, milk, colour, and flavour are combined and added.

4.2.10.3.4. Boiled method

Melted butter or margarine is added to flour (more than two thirds portions) and thoroughly combined. Sugar and eggs are mixed together, then flavour and colour are added. This is gradually added to the flour-fat mixture, stirring well after each addition. At this point, the remaining flour is also added.

4.2.10.3.5. Sugar water method

The first step is to dissolve the sugar in the water, then add all of the other ingredients, excluding the eggs. The eggs are then added and thoroughly whisked.

4.2.10.3.6. All in process

All the ingredients are combined in the mixing dish using this approach. By adjusting the mixer's speed and the amount of time it spends mixing, the mixture is aerated. Next, the batter is added to a prepared pan. Only two thirds of the mold's height should be filled. Put the pan containing the batter in the oven as soon as you can. For 25 to 30 minutes, bake the cake at 375 to 400F.

4.3. BARLEY PROCESSING

Barley is often milled to obtain blocked barley, pearled barley, barley groats, barley flakes and barley flour for human consumption. The sequence of operations in barley milling may be as follows: preliminary cleaning, conditioning or tempering, bleaching (blue aleurone barley), blocking or shelling, aspiration, size grading by sifting, groat cutting, pearling of blocked barley or large barley groats, grading and sifting and polishing. Some of the commercially available barley products are described below.

1. *Pot and pearled barley* are prepared by gradual removal of hull, bran and germ by abrasive action in a stone mill. Production of pot barley is the first stage of pearling, which may remove 7 - 14% of the weight of the grain. Further abrasion results in the removal of seed coat (testa and pericarp), aleurone, subaleurone layers and the germ leaving behind a central endosperm rich in carbohydrates and proteins.
2. *Barley flour* is made by rollermilling of pearled or blocked barley.
3. *Barley flakes* are made by predamping of barley groat, steam cooking of groats or pearled barley, flaking and hot air drying of flakes.

4. *Barley bran* (excluding the hulls) consists of testa and pericarp, germ, the tricellular aleurone and subaleurone layers. Barley bran is obtained as a by-product during barley milling process.

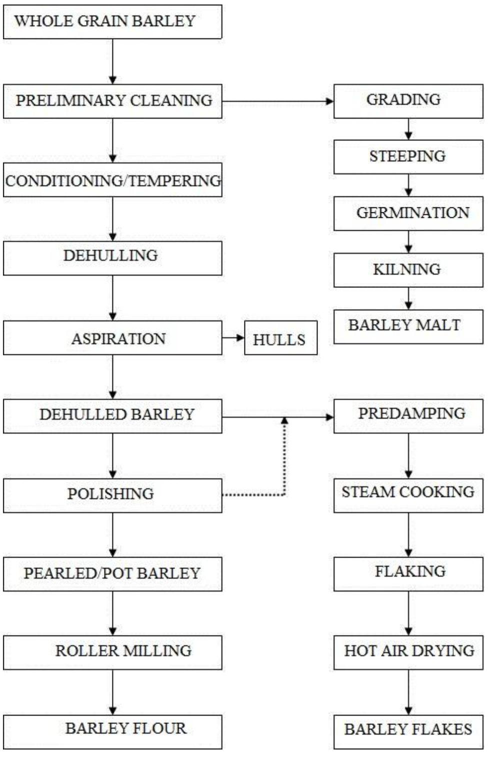


Fig.3.1 Flow diagram of barley processing

4.3.1. Malting

In the production of malt based beverages and malted milk food, barley grain is first converted into malt. The malting process commence with the steeping of barley in water at a temperature of about 12C for 36 hours with frequent aeration, to achieve a moisture level sufficient to activate metabolism in the embryonic and aleurone tissues, leading in turn to the development of hydrolytic enzymes. The wet barley is germinated around 14 o C for a period of about 144 hours. During germination, enzymes migrate through the starchy endosperm, progressing from the embryo end of the kernel to the distal end. In this mobilization phase, generally referred amodification, the cell wall and protein matrix of the starchy endosperm are degraded, exposing the starch granules. After a period of germination, the green malt is kilned at a temperature not exceeding 85 0 C, to arrest germination and stabilize the malt by lowering the moisture levels, typically to less than 5%. In the process, undesirable raw flavours are removed and pleasant malty notes are introduced. The kilning process is also responsible for developing the colour of the malt.

4.3.2. Chemistry of malting

Essentially, malting allows the optimal development of hydrolytic enzymes by the aleurone cells of barley and controlled action of these enzymes to eliminate structural impediments to subsequent easy and complete extraction during mashing. Elucidation of the part played by gibberilic acid in stimulating secretion of □□amylase, endopeptidase, endo□□glucanases and inorganic ions from the aleurone to the central endosperm has encouraged the development of malting modifications.

4.3.3. Steeping

In many respect, the steeping operation is the most critical stage in malting. To produce homogeneous malt, it is necessary to achieve even moisture content across the grain bed. Most barley requires a steeping regime that takes them to 42 - 46% moisture. At the commencement of steeping, the embryo and husk absorb water far more rapidly than does the starchy endosperm. Besides water, barley requires a supply of oxygen to support respiration. Oxygen access is inhibited if the grain is submerged in water for prolonged periods, a phenomenon that dictates use in modern malting regime of steeps interrupted by air rest periods. Additionally the steep water may be aerated or oxygenated. Air rests serve the added role of removing carbon dioxide and ethanol, which are the products of respiratory metabolism and may inhibit germination. A typical steeping regime may involve an initial steep to 32 - 38% moisture, an air rest of 10- 20 h, followed by a second steep to raise moisture to 40 - 42%. The entire steeping operation in the modern malting plants is likely to cover 48- 52 h.

4.3.4. Germination

Germination is generally targeted to generate the maximum available extractable material by promoting endosperm modification through the development, distribution and action of enzymes. Enzyme synthesis occurs during germination in the aleurone and subsequently migrates into the endosperm to effect hydrolysis. During hydrolysis enzyme development follow the sequence: cell wall degrading enzymes, proteases, and then amylases. The process is controlled by maintaining moisture levels within the grain, supplying oxygen, removing carbon dioxide, and eliminating excess heat formed by respiration. Temperature is controlled throughout the germination period, typically in the range of 16 – 20 0 C. Modification of the barley commences at the proximal end of the grain, adjacent to the scutellum.

The rate of modification depends on: (1) the rate at which moisture distributes through the starchy endosperm, (2) the rate of synthesis of hydrolytic enzymes, (3) the extent of release of these enzymes into the starchy endosperm, and (4) structural features of the starchy endosperm that determine its resistance to digestion.

4.3..5. Kilning/ Storage:

Through the controlled drying of green malt, the maltster is able to: (1) arrest modification and render malt stable for storage, (2) ensure survival of enzymes, where appropriate, for subsequent employment in processing, and (3) introduce desire colour and flavour characteristics. Kiln drying is divided into four major phases: (1) free drying down to approximately 23% moisture, (2) an intermediate stage, to 12% moisture, (3) the bound water stage, from 12 to 6% moisture, and (4) curing, in which the moisture is typically taken to 2-3%. Principle changes occurring during kilning is the browning or Maillard reaction. The interaction of reducing sugar and amino acids produces reductones, which in turn can be converted by polymerization to the colourful melanoidins or, by alternative routes, to the heterocyclic pyrazines, thiophenes, pyrrolles, and furans. The oxygen heterocyclics are responsible for toffee or caramel flavours. The pyrazines impart the roasted, coffee like flavours.

4.4.1. Rice Milling

Either small-scale or large-scale rice milling is done. The goal of milling rice is to remove the husk and bran while breaking the endosperm as little as possible. Before processing, paddy is typically dried to a moisture content of 12 to 13%, either on the farm or at the mill.

4.4.2. Milling Procedure

Rice that has been combined harvested typically has a moisture level of around 20% (wet basis), and the grain needs to be dried to about 12% right once for storage. Because entire kernels of rice are the most common form in which it is consumed, paddy is processed to produce a high yield of unbroken kernels.

4.4.2.1. Small scale milling

When milling rice on a small scale, paddy is placed in a mortar and pounded with pestles using the hands or the feet. The rice is pounded for a while before being sifted to remove the husk. Numerous times, the procedure of pounding is repeated. As a portion of the pericarp, testa, and aleurone layers remain on the rice grain, the rice produced using this method is known as brown rice or rough rice and contains more vitamins.

4.4.2.2. Large scale milling

Fig. 2.1 shows a schematic illustration of the rice milling procedure.

4.4.3. . *Cleaning*

The removal of sticks, stones, dust, and other foreign objects is part of cleaning the paddy. The employment of various separation techniques is used to achieve this. First, a screen is used to filter out bigger debris, straws, and string from the paddy. To eliminate weed seeds and sand, it is then passed through a second screen with smaller perforations than the first screen. The paddy then flows as a thin layer into a canal, where dead grains and other lighter contaminants are swept away by an air current. To eliminate metal particles, paddy is lastly run through a magnetic separator.

4.4.4. *Hulling/Shelling*

The cleaned paddy is then run through a machine (disc huller/sheller) made up of opposing rubber and emery rolls, aspirated to remove the husk, then sieved to separate from the broken and unhusked rice. Brown rice or rough rice is the term used to describe rice that has had the hull removed.

4.4.5. *Scouring/Pearling/Whitening*

Scouring, pearling, or whitening is the process of gradually removing germ and bran from rough rice. Pearling cones are used to process the hulled rice. In pearling cones, rice is forced through a small annular space between an inverted cone that has been coated with abrasive and is rotating inside a steel wire cloth-covered conical casing. The bran is forced through the gaps in the wire cloth as it descends. Rice Bran, a by-product of the scouring process, is utilised as animal feed. Rice bran oil is also extracted using it.

4.4.6. Polishing

The inner layers of the bran-containing rice grain are polished by a device known as a brush. The last bran fraction is eliminated in this machine. Now, the grain is referred to as polished rice.

4.4.7. Parboiling of Rice

In India, the method of parboiling rice was created to stop losses from breaking during manual pounding, especially with long-grained kinds. This method involves soaking paddy in extra water, cooking it in the husk, and pregelatinizing the starch. Due to the uniform mass of gelatinized starch, any hairline cracks are filled, preventing breaking during milling. After that, the paddy is dried and drained.

Many methods can be used to parboil food. The overall plan is to steam heat the paddy at 15 lb pressure for 10 to 20 minutes in order to hydrate (steep) it to a moisture content of 32 to 38% and partially gelatinize the starch. In addition to enhanced milling yields (66–70%), increased insect resistance, and a firmer cooked rice texture, parboiling also results in changes to the rice's physico-chemical compositionThe water soluble vitamins (niacin, riboflavin, and thiamine) that are present in the germ and pericarp move into the endosperm during soaking and cooking, increasing the nutritional value of parboiled rice. Even the proteins on the grain surface are denatured, turn into an insoluble substance, and are not eliminated after washing and cooking.

4.4.7.1. Advantages of parboiling of rice

- Parboiled rice is simple to dehusk, and the harder grain results in fewer milling losses.

- A higher yield of head rice after milling because the kernels are more durable.
- Milled parboiled rice has greater resistance to insects and fungus infection.
- Because the water dissolves the vitamins and minerals found in the hulls and bran coat and transports them into the endosperm, the nutritional value of rice increases after parboiling.
- • Milled parboiled rice has higher levels of thiamine, riboflavin, and niacin than milled raw rice does.

  • When cooked, rice that has been parboiled does not become a sticky mass.

4.4.7.2. Disadvantag of parboiling of rice

- It has a bad smell due to prolonged soaking.
- It has a dark colour due to heat treatment.
- It requires prolonged cooking time and more fuel.
- Since the oil content is more, the polisher may got choked.
- The heat treatment may destroy antioxidants. Hence, rancidity may develop.
- Due to the high moisture content, mycotoxins may be formed.
- Drying cost is added to the total processing cost, extra capital investment.

4.4.7.3. Milling quality

The degree to which the endosperm is still intact after milling is referred to as milling quality. Total milling yield, also known as head rice yield (milled rice kernels with an endosperm length of at least three quarters), is a measure of the quality of the milling process. The procedure of milling should not result in breakage.

4.4.8. Rice based instant foods.

IdJi, dosa, papads, vermicelli, crispies, muruku, etc., which are made from wet-ground rice paste or dry-ground rice flour; and fermented or deep-fried preparations made from a mixture of rice and pulses are just a few examples of rice-based products that have been popular in India for a long time.

4.4.9. RICE Based BREAKFAST CEREALS

Rice has a significant amount of starch. In its natural state, the starch is insoluble, flavourless, and inappropriate for human ingestion. For anything to be pleasant and accepted, it must be prepared. There are two types of rice breakfast cereals: those that need to be boiled before serving and those that can be eaten straight from the packet. The ready-to-eat rice cereals can be made from the whole grain of rice or its milled byproducts. Rice is precooked, dried, flaked, or formed into dough in prepared cereals. It is then toasted either alone or in combination with other cereals after being expanded or puffed.

The length of cooking, steam pressure, temperature of the raw ingredients, and toasting procedure all have a significant impact on the quality of the finished product. Flouring ingredients, vitamin B complex, minerals, and protein-containing ingredients may be added to boost the nutritional content. According to their intended usage or physical properties, breakfast cereals can be grouped into a wide variety:

1. Traditional breakfast foods that require cooking: Cereals that are sold as processed raw grains.
2. Traditional instant hot cereal - Cereals that can be made with merely boiling water and are sold in the market as cooked grains.
3. Grain products that have been cooked and altered so they can be divided into flaked, puffed, or shredded cereals are used to make ready-to-eat cereals.
4. Ready-to-eat cereal mixtures, which typically contain cereals as well as other grains, legumes, oil seeds, and dry fruit products.

5. Extra cereal products. These are cereal products that, because of specialised production processes or intended uses, don't fit into the categories listed above. Cereal nuggets and baby nibbles are two examples of goods in this category.

4.4.9.1. RICE FLAKES

The conventional process is soaking the paddy in warm water for the entire night, emptying the water, roasting it in hot sand for one minute, and then continually running it through an edge runner or manually pounding it to flatten the kernels. There is a large loss in this procedure since the kernels crack while flaking. In the improved process, once the rice has been cooked in a rotational cooker for 20 minutes at 8.2 to 8.6 kg/ern pressure, steam pressure is released to release gases. Cooking could go on for one to two hours, depending on the kind of rice used. When cooking rice, an agent must be added to prevent sticking and lumping of the cooked rice.

When finished cooking, there should be around 33% moisture left, and the surface is hoover-dried. The cooked rice is first dried to a moisture content of about 17%, followed by hours of tempering, flaking on big smooth rolls, and toasting. The blistered flakes are then refrigerated, packed, and dried to a moisture percentage of 2% to 3%. Roller flakes are used to remove the kernel fracture. In contrast to oven-puffed rice, rice flakes often melt in milk more quickly.

4.4.9.2. PUFFED RICE

1. Puffed rice is a very popular ready-to-eat breakfast cereal and snack in India because of its lightness and crispness. It is also a popular food item produced in many countries in a variety of forms, such as puffed rice balls, bars, fatty pastes, chocolate, and boiling sugar confectioneries.
When rice is heated for a brief period of time at a high temperature (HTST), the rice puffs as a result of abrupt expansion of steam in the gaps between the starch granules.
The rapid migration of the water vapour out of the particle causes dehydration, which maintains the particle's larger condition. The moisture content should be kept in puffed products at about 3% in order to maintain the proper crispness. It is possible to categorise in two broad categories.

1) Processes involving pressure decreases, which include quickly delivering superheated particles into a location with lower pressure.
2) Procedures involving air pressure that depend on the quick application of heat to provide the necessary rapid vaporisation of water. By moving the hot substance from the environment into an empty space or by opening the seal on a vessel holding a substance that has been equilibrated with high-temperature steam, the pressure can be reduced safely.
Sand, air, oil, rollers, and ovens are examples of atmospheric pressure processes, whereas extrusions and guns are examples of pressure-drop processes.

4.4.9.2.1. SandPuffing .

This method is commonly used in India, where parboiled rice grains with an initial moisture content of 11–12% are combined with 2% salt and a small amount of water to raise the moisture content to 16–29% (wb). Moistened rice grains are then heated (called tempering) for 30–8 hours to help the moisture balance within the grains. The treated rice grains are dried until they are between 10 and 11 percent (wb) dry either in the direct sunlight or by conduction heating in a hemispherical metallic container while being continuously stirred. A small amount of rice is roasted for 6 to 20 seconds at an ideal sand temperature of 230 to 275 QC to produce puffed rice with an expansion ratio of 8 to 10. The laborious procedure has a relatively low production rate of 2 to 2.5 kilogramme per hour.

Rolling, puffing and rolling In roller puffing, dough with a moisture content of 8 to 18% is fed into the rolls at temperatures ranging from 190 to 440 Q C. Items become puffy at a moisture content of 6 to 7%. The internal circulation of high-temperature fluid media in the cylinder or radiant heat are both used to heat the rollers.

Oil Swirling Parboiled rice that has been cooked through is puffed in vegetable oil at 200 to 220 QC to obtain an expansion ratio of 5 to 7.

Air Blowing A blast of air at 200 to 300 QC for 7 to 10 seconds is provided to pretreated rice with a moisture content of IOta 12O/ to produce puffed rice with an expansion ratio of 8 to 10.

Puffing a Gun Using this technique, raw milled rice and other grains can be puffed without the need for pretreatment (parboiling), which is required when utilising other techniques. In a spinning pressure vessel that is heated from the outside, pro-moistened pearled or unpearled grains are fed. Since the ideal pressure varies from grain to grain, the sudden release of chamber pressure causes the superheated water to abruptly turn into steam, resulting in the porous structure of the puffed items In other circumstances, superheated steam is used to build pressure in the pressure vessel up to 15.1 kg/ern at a temperature of 241.6 QCat the gun by superheating the grains to 272-337 "C (521 to 638 OF).
After a brief cooking time, the gun is rapidly opened to release the puffed rice. The initial moisture content of the grains and achieving the appropriate pressure in the shortest time. very important for gun puffing

4.4.9.2.2. Extrusion Puffing

Rice-Based Products In order to create puffed breakfast cereals and snacks, hot, pressured dough is forced through an opening and into the atmosphere. Both single- and twin-screw extruders are employed.The abrupt expansion of water vapour caused by the sudden release of excess pressure causes the extrudate's volume to expand by several times. High and continuous production rates, a greater variety of product forms, and easier control of product density are some of the apparent advantages the technique appears to offer over gun puffing. Gun puffing can yield an apparent specific volume that is equal to or greater than that. Extrusion puffing, on the other hand, can only be done with dough, as opposed to gun puffing, which may be done with entire grain kernels.
The rice flour mixture is moistened with water (or steam) and regulated to ensure a steady supply of extrusion material. An estimated 60–75% of this mixture is expandable starch. The resultant mass is compacted by a rotating screw inside a barrel that may be heated with steam or electrical band heaters. As discharge approaches, the screw's thread pitch becomes increasingly narrower. In some extruder designs, the rice premix is placed straight into the extruder. The water or steam that is injected into the barrel is blended with the premix. The dough is cooked by steam, sheared, and pressed until the die head temperature and pressure are 150–175 QC and 2.4–35.2 kg/ern, respectively.

In these conditions, the dough is extremely pliable and easily adapts to complex orifice configurations The expansion of the dough pieces as they leave the dice hole may even last for a few seconds due to the dough's hardness while yet remaining malleable and the water's continued boiling off. The pieces are also dried in a hot air oven before being cooled and packaged.

4.4.10. QUICK COOKING RICE

It is a well-liked product in the US, Japan, and several other western nations. Depending on the variety, ageing, kind of rice (raw or parboiled), and particular textural preferences, ordinary milled rice needs 20 to 30 minutes to cook to a culinary acceptability. Instant or quick cooking rice is whole grain, naturally dehydrated, and precooked rice that may be made in only 2 to 5 minutes. The rice that cooks quickly must be simple to produce in large numbers and have good storage stability for 6 to 12 months at room temperature. It is necessary to pre-cook the rice and partially gelatinize the starch in water, steam, or both in order to make quick-cooking rice. Usually, the cooked or partially cooked rice is dried in a way that preserves the porous, open structure of the rice grains. The finished product must be devoid of lumps, consist of dry, separate kernels, and have between 1.5 and 3 times the bulk volume of uncooked rice. The quick-cooking methods that are commercially viable include the following:

1. The soak-boil-steam-dry technique Raw milled rice is soaked in water to a moisture content of 30% at room temperature before being cooked in boiling water to a moisture content of 50–60% (wb), either with or without steaming. To preserve a porous structure, the product is carefully dried to 8 to 14% moisture after being further boiled or steam-treated to enhance the moisture content to 60 to 70% (wb).

2. Expanded and pre-gelatinization method: Rice is extensively gelatinized by soaking, boiling, steaming, or pressure cooking before being dried at a low temperature to generate fairly dense glassy grains. The grains are then expanded or puffed at a high temperature to provide the appropriate porosity structure in the finished product.

3. Rolling or "bumping" method: After being pregelatinized as previously discussed, rice is rolled or "bumped" to flatten the grains and dried to a somewhat hard, glassy product.

4. Dry heat treatment method: To dextranize, fissure, or enlarge the grains, rice is heated to temperatures between 65 and 82 QC for 10 to 30 minutes, or to 272 QC for 18 seconds. There is no steaming or boiling. It takes less time to cook the product than untreated grains.

5. The pricey method of freeze-thaw-drying involves precooking rice, which is then frozen, thawed, and dried.

6. Gun puffing: This procedure entails preconditioning the rice to 20–22% moisture content before steaming it in a retort for 5–10 minutes at 3.5–5.5 kg/ern. The final step is to puff the product into a vacuum or ambient pressure. The ideal terminal condition is at 165QC at moisture levels of 20–25%.

Additionally, chemical processes have been utilised to create rice that cooks quickly. This technique involves soaking rice in a saturated sodium chloride solution (NaCI) at a temperature of around 80 QC, which partially gelatinizes the starch.

4.4.11. Types of Quick-cooking Rice

Different kinds of quick-cooking rice are produced by varying moisture contents, precooking temperatures and periods, dehydration circumstances, and other processing factors. These range from slightly undercooked rice that needs 10-15 minutes to cook to good quick rice that just needs 5 minutes to prepare.

A commercial rice product called "Minute Rice" can be quickly rehydrated with hot water and, when boiled with water, produces a fairly excellent result.

4.4.12. RICE BASED INFANT AND BABY FOODS

Because of their special nutritional needs, babies frequently start eating solid foods with rice cereal. This is due to its simple digestion, lack of allergens, low fat content, and bland tasting. Many baby foods are made using rice, either in the form of rice flour or as granulated rice. Baby foods are made with rice flour, glutinous rice flour, and rice polishing. Baby food products are frequently thickened with rice flour. It doesn't add any strange ingredient names to the label and combines well with other foods like vegetables and proteins. Rice infant cereals are marketed as ready-to-eat cereals and as dry, precooked flakes for rehydration. The type of rice used in infant cereals that are ready to eat is crucial. To prevent retrogradation during storage, which leads to the production of a very hard gel and the separation of water, medium and short grain cultivars with reduced amylose contents are utilised. The production of pre-cooked newborn rice cereals is the baby food industry's primary application for rice.

4.4.13. Pre-cooked Rice Cereal

As a baby's first solid food, rice cereal that has already been cooked is commonly recommended. The cereal must be simple to reconstituted with milk or formula and have the fewest possible lumps. Preparing and heating cereal slurry is the first step in creating precooked baby food. The goal is to pre-cook the rice and change the starch's crystal structure to one that is amorphous. Amylase enzymes from an industrial source may be accurately added to the slurry to aid in the digestion of the rice starch.

An atmospheric drum dryer is used to dry the prepared rice slurry. To produce rice that is simple to digest, various factors are managed, including the thickness of the coating on the drier surface, the distance between the drums, the surface temperature, the drum speed, and the slurry's flowing characteristics. The thickness of the dryer sheet and the flakes' size distribution both affect the bulk density of the cereal. Due to the large starch content of rice, even a small change in the solids content has a significant impact on the apparent viscosity of cooked rice cereal. To produce a completed good of great quality, the solids, drum speed, and drum temperature are regulated. In markets where dramatic climatic variations are uncommon, packaging the finished product in particular paperboard carton containers seems to be a frequent practise.

Some precooked rice cereals flavoured with strawberries or apples seem to be well received by consumers. Similar to how precooked infant cereals are typically prepared, these items are made. Cooked cereal components, fruit, sugar, oil, vitamins, and minerals are flaked and packaged after being dried on an air drum dryer. Fruit cereals need moisture-proof packaging since the fruit and sugar are hygroscopic. To increase the product's shelf life, an antioxidant may be added to the packing material However, since infant foods need special consideration for safety seasons, a special permit from the Food and Drug Administration (FDA) may be required for such practises. If packaged in a hermetically sealed container, rice-based cereal may go bad. The material that allows for both gas and moisture vapour transport is the most appropriate packing material for such a product. The majority of precooked baby cereals come in paperboard boxes. The interior of the box has a bleached manila liner, which seems to be a pretty typical practise. A printed paper label with glue mounting covers the carton. The package is sifted and protected from insects by the tight wrap.

4.4.14. Extrusion-cooked Baby Food

Extrusion cooking is a novel technique for making baby foods, in addition to drum drying of rice-based baby foods. The type of extruders utilised, the rice flour's particle size, the rice-water mixture's moisture content, and the extrusion conditions are just a few of the key variables affecting the qualities of extruded rice baby foods. The Kasetsart" infant food, created by Khasart University in Bangkok, Thailand, is an illustration of extrusion-cooked rice-based baby foods. It has 13% full-fat soy flour, babymate, and 72% rice flour. Soups and casserole dishes are typically produced with a blend of 75% milled rice flour and 25% dehulled mung bean.

4.4.14.1. Formulated Baby Foods

Products made from rice cereal are frequently used to prepare infant foods. In addition to being a food item, rice also significantly affects the consistency of infant foods. The physical characteristics of the finished product are greatly influenced by the type of rice used in these goods. Long-grain rice causes the product to thicken during storage (starch retrogradation) and finally form a very stiff gel and water separation because of its increased amylose content. A major flaw in a product is the existence of loose liquid inside a glass container.A useful stabiliser for canned and frozen food products is glutinous rice flour. A decrease in the product's amylose/amylopectin ratio results in the stability. Junior grade baby food is a type made for babies that are more developed.Baby food from Junior's has a rougher texture. They assist the infants in gaining a taste for solid meals. Granulated rice is used in the formulation of several junior vegetable and meat products to create the junior grade infant feeds. In order to prevent particles from settling out and forming a mat at the bottom of the jar, care must be given when preparing junior baby foods. Modified waxy-maize starch is typically used to bind the junior-sized particles evenly throughout the product.

4.4.15. FERMENTED RICE PRODUCTS:

Infected Rice This product is made by mixing cooked rice with water and letting it sit for an entire night. After draining, the water is either combined with buttermilk and salt for a direct consumption option or used to sauté vegetables. The rice is combined with salt and curd (dahi). Fermented rice has been used to isolate S. faecalis (2.7x107 per g), Pediococcus acidilactict (2.7x107 per g), Bacillus sp. (1.6x108 per g), and Microbacterium flavum (1.1 * 108 per g). In 16 hours, the pH drops from 6.1 to 5.7. Volume, amino nitrogen, or free sugar remain unchanged. 11.8.2 Idli, Dosa, and Dhokla are small, acid-leavened, steamed cakes made by bacterial fermentation of a thick batter made from rice that has been properly washed and dehulled The black gramme is finely ground, whereas the rice is coarsely ground. Very good dosa batter. unlike idli batter, but with finely ground rice and black gramme. The dosa is immediately fried into a thin, reasonably crisp pancake and consumed right away after fermentation. The preparation of dhokla is similar to that of idli, with the exception that dehulled Bengal-gram pulse is used rather than black gramme pulse. Instead of steaming in a covered idli steamer, the fermented batter is placed into a greased pie pan. The procedure for preparing idli is shown in Fig. 11.1 for your convenience.

4.4.16. RICE NOODLES AND PASTA

Nobility (Rice "Pasta" In Asia, rice noodles are a common rice product and are eaten as soups or as snacks. In Taiwan, China, and eastern southern Asia, they are also known as bifun (bihon) or vermicelli, while in Japan, they are known as harusame. Typically, they are made with highamylose rice flour.

4.4.16.1. Traditional Method of Manufacturing Rice Noodles

In order to reduce product rancidity, freshly polished rice is suggested. Brokens might be utilised to cut costs. The presoaked rice is wet-milled using vertical steel mills and horizontal stone or concrete mills. Regular rice noodles should normally avoid microbial development. But in Thailand, unique rice noodles undergo fermentation during prolonged soaking. Brokens are soaked for three days to allow for fermentation with Lactobacillus and Streptococcus species, which lowers the pH from 7 to 3.5. After one day of offermentation, the protein level drops to 1.6 percent, and after three days, it drops to 1.1%.

4.4.16.2. Instant Rice Noodles

In Asia, instant rice noodles are sold in stores. The term "instant" denotes that the dried rice noodles can be fully rehydrated and are ready to serve in 5 minutes, with the majority taking less than 3 minutes. The manufacturing procedure is comparable to what was previously covered. A two-extruder configuration is used in moderri plants to make the product. For instant rice noodles, the product's size or diameter is crucial. Rice noodles made instantly are thinner than 0.68 mm. The product cannot be considered instant rice noodles if the diameter of the rice noodles is greater than 0.78 mm.

4.4.17. Snack Food Noodles

One type of noodle, called mitaimu (or bilabial), is consumed as a snack. It is a short, wide-diameter wet-type noodle that is typically consumed in the summertime with syrup and ice. Mitaimu is also consumed in Taiwan with beef, leeks, or green onions. As condiments, salt, monosodium glutamate, and pepper are always included. The production of mitaimu is comparable to that of regular rice noodles. Hot water can be used to gelatinize some starch during the mixing of flour and water for binding purposes. Typically, mitaimu is less than 10 cm long and has a diameter of 3–5 mm. Since it is extremely difficult to dry or rehydrate the dried mitaimu, there is no dried product on the market. Only indica rice with a high amylose concentration is used as the raw material, much like with rice noodles. To change the texture of the food, some starches are added. These include corn, tapioca, and sweet potato. Its suppleness is increased with the aid of sweet potato starch. Its hardness is diminished by maize or tapioca starch.

4.4.18. Sheeted or Flat Noodles

Sheeted or flat noodles are very well-liked throughout Asia, especially in Taiwan, Thailand, and Japan. Wet-milled flour is typically preferable, but dry-milled flour is also an acceptable starting point. A milk layer is traditionally formed in a drum and then cooked with steam. The gelatinized sheets are sliced into noodle-like strips after being partially dried. An extruder is utilized in a modern factory for both cooking and shaping. Traditional uses call for indica rice with a high amylose content. Some Japanese rice that isn't waxy (contains amylose)

CONCLUSION

The milling of wheat is done on rolls-both fluted and smooth, where in the cleaned and conditioned wheat is first opened and endosperm in the large bran pieces is scraped on the fluted rolls of break system. The endosperm particles thus obtained are purified. A portion of purified stock is packed m; sooji, while remaining material reduced to desired particle size in reduction system to obtain maida. The endosperm portion, which cannot be further rendered free of bran is ground to desired particle size and extracted as resultant atta. The bran fractions free from endosperrn called coarse (flake) bran, and fine (rough) bran are obtained at the end of break and reduction systems, respectively.

In the break system, we produce coarse, medium and fine semolina; coarse and find middlings are produced. These are purified to get clean endosperm particle, free of bran, on purification. These purified material as well as dunst (coarse maida) produced in break system are sent to reduction system to produce maida, and fine bran.

Value addition to rice, in addition to its traditional use as a table food, helps to increase rice consumption. It is achieved through many ways: processing into products with a precise utilization (breakfast cereals, puffed rice, quick-cooking rice, noodles &. pasta, baby foods); combining multiple ingredients in 'products that promote health and wellbeing (fruited cereal flakes, ready mixes, for traditional foods); and improving quality by adding nutrients (fortification). Various types of processes used in value addition include puffing, extrusion, fermentation; fortification; nutrient supplementation; extending the shelf-life of products through drying, canning and appropriate storage; and imparting visual appeal through roasting; freezing, toasting, baking, grinding, flaking, the use of additives (colours and flavours) and packing.

EXCERCISE

1. What are staple foods?

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2. What is difference between Durable and Perishable ?

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3. If the bran or outer covering of a food grain is removed which is the nutrient that suffers most?

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4. Name the amino-acids deficient in cereals.

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5. Define conditioning or tempering of wheat.

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6. Write about importance of gluten in durum wheat for pasta making.

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7. Define wet fraction process.

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8. Define bread making process

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9. Define staling of bread.

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10. Define biscuitn making process

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11. Define baking powder.

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12. Define **Flour batter method**

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13. Define role of fat in cake.

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14. Describe how the rice grains blow up.

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15. What are the various puffing techniques for rice grains? provide examples of
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16 What are the different puffing techniques?
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17 What are the various ways of puffing?
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18 What is the difference between ordinary milled and quick-cooking rice?
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19 What are the main unit operations in preparation of quick-cooking rice?
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20 What are the main features of rice baby foods?
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21 List the various forms of rice used in preparation of baby foods?
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22 What is the main reason to use medium and short grain varieties in preparation of ready-to-eat baby cereals?
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23 List the various ingredients used in preparation of baby foods .
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24 What are the main important operations in preparation of precooked baby cereal?
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25 List the parameters affect the final quality of easy-to-digest rice product in drum drying .

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26 List the various names & types of rice noodles.

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27 What are the requirements in manufacturing rice noodles?

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28 What is the advantage of using a twin-screw extruder to produce rice noodles?

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KEY WORDS

Milling of wheat: Here, it refers to roller flour milling of wheat to produced maida, sooji, resultant atta and bran.

Grinding rolls: They are chilled cast iron rolls manufactured by centrifugal casting of hot / molten metal - to have desired range of hardness upto certain depth.

Reduction system: Endosperm particles of various sizes and purify, produced and processed by break and reduction systems, respectively, are ground down in reduction system to produce maida.

Roll Surface: It is a system of expressing the tota1length roll

Milled Rice-Paddy from which husk, germs and bran layers have been substantially removed by milling machinery, also known as raw rice.

Broken Rice- Dehusked milled rice consisting of broken grain or less than 3/4th of the whole grain but not less than 1I4th.

SOME USEFUL REFERENCES

1. Bor, S.L. 1980. Rice: Production and Utilization, The AVI publishing company; INC; Westport, Connecticut. - 2. Juliano, B.O.1985. Rice Chemistry and 'Iechnology, The American Association of Cereal Chemists, Inc; St.Paul, Minnesota, U.S.A

3. Dendy, AY.D. 2001.Cereals and Cereal Products: Chemistry and Technology, Aspen Publishers, Inc; Gaithersburg, Maryland.

4. Mercier Ch. & Cantarelli, C.1985. Pasta and Extrusion Cooked Foods, The Elsevier Applied Science Publishing Co., Inc; 52, Vanderbilt Avenue, New York.

5. Steinkruss, K.H. & Cullwen, R.E.1983 .Hand Book of Indigenous Fermented Food's,' Marcel Dekker, Inc; New York.

6. Champagne, E.T. 1998. Rice Chemistry and Technology, The American Association of Cereal Chemists, Inc; St.Paul, Minnesota, U.S;A

7. Robin Guy. 2001. Extrusion Cooking-Technologies and Applications, Woodhead Publishing Limited and CRC Press LLC, Abington, Cambridge CBI 6 AH, England.

UNIT V: PROCESSING TECHNOLOGY OF PULSES AND OIL SEEDS

Unit V. PROCESSING OF PULSES AND LEGUMES

Structure:

i) Cleaning:

ii) DehuUing:

ill) Size Reduction and Flaking:

• Size Reduction of Oil seeds by Grinding:

• Heat Treatment:

5.1.5.5.1. MECHANICAL OIL EXPULSION METHODS

i). Ghanis

ii) Press Type Oil Expellers:

iii) Mechanical Screw Expellers:

5.1.5.5.2. **SOLVENT OIL EXTRACTION METHODS**

5.1.5.6. **REFINING OF EDIBLE OILS**

5.1.5.7. BY PRODUCTS OF OIL PROCESSING

1. Oilcake or Meal:
2. Oil:
3. Husks and Shells:
4. Lecithin:
5. Gums:
6. Residues:

5.0.PULSES AND LEGUMES:INTRODUCTION

Grain legumes (also called as beans or pulses) are second only to cereals as a source of human and animal food. Legumes or pulses are general names given to plants like beans and peas that are distinguished by having their grains in pods. Beans, lentils, peanuts, peas, and soybeans are some of the common .legumes consumed by humans. The term pulses, as used by the FAO, is reserved for crops harvested solely for the dry grain. This therefore excludes green beans and green peas, which are considered vegetable crops. Legume seeds have twice as much protein as grains. They are also high in iron and B vitamins. Some legumes, such as clover and alfalfa, are used as animal feed. Split pulses are popularly known as *Dals* in India (for example, *chana dal* [Bengal gram], *tuver dal* [red gram], *mung dal* [green gram] and *urad dal* [black gram].

In India, legumes/ pulses are being consumed as part of a primarily cereal-based diet from time immemorial. Legumes/pulses are the main source of protein and are 2-3 times richer in proteins than cereal grains. Pulses are 20 to 25% protein by weight, which is double the protein content of wheat and three times that of rice. For this reason, pulses are sometimes called "poor man’s meat".

The food legumes are classified in two categories: the legumes in which energy is stored as starch (e.g. pulses) and the ones in which it is stored as fat or oil (e.g. peanut and soybean). Oilseed legumes are the major contributor to world edible oil supply as well as protein-rich diets and cattle feed. The soy bean in India is exclusively used as a source of oil and the meal as a protein rich animal feed. Inhibitors hold back the popularization of soy bean as a food legume in Indian diets. The trypsin inhibitors present in the soy bean and their removal before consuming is a stumbling block. The trypsin inhibitor does not get destroyed in

ordinary cooking. Organoleptic factors such as flavour and odour, and the presence of flatulence factor also have to be tackled. Special processes are available to eliminate or at least reduce these factors to a more acceptable level.
India traditionally has been the largest producer and consumer of pulses (food legumes) in the world, accounting for 25% of the global output. The current production of all pulses/ legumes in India at 91.0 million tonnes is inadequate to meet the huge domestic demand. India is also the world's largest importer of pulses. Canada, Myanmar, Australia and the United States are significant exporters of pulses and significant suppliers to India.

Due to a sea-change in the dietary habits in view of the growing health consciousness and preference for vegetarian proteins, there is an increasing demand for grain legumes in the developed world not only as food but also for feed.

Vegetable oil industry is one of the major industries in the world with a huge turnover next to petrochemicals. Vegetable oils not only play a significant role in nutrition but find uses in diverse applications. Vegetable oil is the only molecule which can be used as food, fuel and fabulous chemicals. In India itself, the turnover of this industry is about Rs. 70,000 crores with about Rs. 25,000 crores import-export trade. Today the whole world is looking at vegetable oil as an alternative to petroleum products. Several research programmes have been initiated globally for the development of vegetable oil-based novel organic intermediates as substitutes for petrochemicals and specialty chemicals. Unfortunately, India's consumption of vegetable oils is more than its production and it is importing about 5 million tonnes of oils every year.

With the technology upgradation, it is possible to enhance the production of the oil. Oilseeds and animals are the main source of fat. The largest source to oil is seeds of plants such as groundnut, rapeseed, mustard, sesamum, sunflower, soybean, castor seed and linseed. Unit 5 deals with the production, statistics, acreage and agronomical practices for production of oilseeds of different types. It also explains the composition of oil and its physical properties. Unit 6 deals with the various types of oilseeds, oil extraction methods including mechanical expulsion and solvent extraction. It also explains the methods of refining edible oils to make them suitable for human consumption. Utilization of deoiled cake for various purposes is also discussed in the unit

5.0.2. Composition of Legumes

Pulses supply the same amount of calories as cereals i.e. 350 kcal per 100 g (1464.4 kj/100g) dry weight. While pulses are generally high in protein, and the digestibility of that protein is also high, they often are relatively poor in the essential amino acid methionine. Grains (which are themselves deficient in lysine) are commonly consumed along with pulses to form a complete protein. It is not safe to eat raw or undercooked kidney beans and soya beans because of the anti-trypsin factor (or trypsin inhibitor) that prevents the assimilation of the amino acid.

Carbohydrates Content: Legumes usually contain large amounts of carbohydrates ranging from 24 to 68% and starch is the main carbohydrate along with oligosaccharides. Oligosaccharide raffinose is predominant in legumes. It is known to cause indigestion and flatulence that cause discomfort, abdominal rumbling, cramps, pain and diarrhea. Besides they also contain cellulose and hemicellulose.

Protein Content: The protein content in pulses range from 17 to 30 per cent about twice or thrice of that in cereals. Soybean with a high of 42 per cent protein is the highest protein containing pulse. Proteins from legumes generally have all the essential amino acids, but is deficient in tryptophan, methionine and cysteine. This deficiency can be made up by taking cereals and pulses together.

Fat Content: The fat content of most pulses is low i.e. 1-2 per cent, however some legumes, such as peanuts (with 50 per cent), soybeans (21 per cent) and winged beans (17 per cent) contain considerable fats. Pulses and legumes are also a rich source of dietary fiber.

Minerals and Vitamins: Legumes are a good source of minerals such as calcium, iron, copper, zinc, potassium, magnesium and phosphorous. These are reputed to lower blood cholesterol and help diabetics by reducing post meal rise in blood sugar. They are gradually absorbed in the body, resulting in low rise of blood sugar. Legumes are rich in vitamins especially vitamin B complex and also beta-carotene and niacin. Germinated chickpea and green gram contain plenty of ascorbic acid.

Anti-nutritional Factors: Legumes contain some compounds that have a negative food value. These include protease inhibitors, hemagglutinins, saponins, cyanogenic glucosides, lathyrogens, phytate, raffinose and tannins. Most of these anti-nutritional factors can be neutralized by soaking in water before cooking the pulses. Peanuts, because of their high moisture content at harvest, may support mold growth and development of toxic metabolites of molds such as aflatoxins. Heat processing and cooking can help reduce aflatoxin levels to some extent.

5.0.3. Milling of pulses

In home scale as well as commercial practice, there are two methods of milling:

1**. Wet Method**

2. Dry Method

1. **Wet Method:** In this method, pulses are soaked in water for 2 to 8 hours prior to drying. In different to dehusk pulses like arhar (pigeonpea, tur), urad (black gram) and moong (green gram), the soaked pulses are treated with red earth before it is dried. After drying, the pulses are subjected to dehusking and splitting which has been explained through flow diagram at Fig. 1

Pulses

↓

Cleaning

↓

Soaking in water,2 to8 hours

↓

Mixing with red earth → Easy to dehusk pulses

(for hard to dehusk pulses)

↓

Drying

↓

Dehusking

↓

Splitting

↓

Dal

Fig. I: Wet method of Pulses

2.Dry Method: Here, after cleaning and grading, the pulses are subjected to pitting. Operation 'pitting' means producing scratches, dents and cracks on the hard seed coat by passing the pulses through Roller Dehusker. Now the pitted pulses are smeared with 150-250/g of oil perquintal of pulses, stored for 12 hours to 3 days. During this period, oil diffuses in between the husk and cotyledon which loosens the husk. To further loosen the seed coat, it is treated with 2.5 to 3.5 kg of water per quintal of pulses and stored overnight. Next day, after drying and cooling, it is subjected to dehusking and splitting as shown through flow diagram at Fig. 2.

Pulses

↓

Cleaning

↓

Pitting

↓

Oil smearing, l50-250g of oil/quintal of pulses

↓

Storage for 12 hours to 3 days

↓

Water treatment

1.5 to 3.5 kg of water/quintal of pulses

↓

Drymg

↓

Dehusking

↓

Splitting

↓

Dal

Fig. 2: Dry Method of Pulses Milling

5.0.3.1. Processing Pulses

In India most of the pulses are consumed in dehusked and split form. Thus processing of pulses assumes a lot of importance. Pulses processing industry helps in processing the raw grain legumes/ pulses into edible form. Processing activity is undertaken as follows. Processing Operationsare as follows:

1. Cleaning and grading
2. Drying
3. Loosening of husk
4. Dehusking
5. Splitting
6. Polishing

5.0.3.1.1. Cleaning and Grading This is an important unit operation in pulses milling industry. The raw pulses received by the plant needs to be cleaned and size graded for getting good quality dal and higher recovery. Also after every dehusking operation, the grain lot has to be subjected to sieving to separate out husk, brokens, splits, and whole (unhusked) pulses.

Normally two, types of cleaners are in use viz. Reciprocating air-screen cleaners and Reel screen cleaners. The Reel screens are better than reciprocating screen cleaners due to following reasons:

a) Reel screen cleaners operate at low noise levels.

b) It requires insignificant repair and maintenance expenditure.

c) Its power requirement is almost half as compared to reciprocating cleaners.

d) It causes less dust pollution.

The reciprocating air screen cleaners consist of two screens (sieves) and an aspirator air blower. The aspirator/ blower separates out the lighter material like dust, stalk, dried leaves, husk etc. The upper screen with larger perforations is called Scalper. It scalps out the larger size material while the smaller size material fallsthrough the screen over second screen having smaller perforations. The desired material bigger in size than perforation size moves over the screen and is collected in discharge trough fitted at its tail end.

The smallest sized material passes through the screen and is collected through a trough.

5.02.1.2.Drying of Pulses: In pulse milling industry, drying of pulses is an important unit operation. The pulses received from farmers 'mandis' or traders generally have higher moisture and thus some degree of drying is essential before it is considered fit for storage and milling. Also during loosening of husk, the pulses need to be dried after it has been treated or steeped in water and stored overnight. Due to economical reasons, all the mills adopt sun drying during the dry season. For this, mills have cemented floor located generally at the backyards of the mill. At places where space is the limiting factor, roofs are used for the purpose. The sun drying is done for 1-6 days as per the requirement.

5.0.2.1.7. Loosening of Husk: This isthe most important unit operation in pulses milling. Effectiveness of this operation decides the total recovery and quality of milled dal. In general, loosening of husk is done by two ways.

a) Wet Method

b) Dry Method

a) Wet Method: In this method, the cleaned and graded pulses are steeped in water for 4-12 hours, mixed with red earth for 12-16 hours and later sun dried to keep the moisture at 10-12 %. Steeping, facilitates easy dehusking and splitting. Longer the period of soaking, greater is the loosening of husk and caving in of the cotyledons on drying, which makes it easy to mill (dehusking and splitting).

Yield is also increased due to lesser breakage. However the cooking quality of dal is adversely affected as it takes longer time to cook. Treatment with red earth is said to impart a good yellow colour to the finished product. It also helps to remove small patches of adhering husk due to its mild abrasive quality.

b) Dry method: Dry method for loosening of husk is in vogue in most of dal mills of the country. In this method, husk is loosened by oil smearing, water application, tempering and sun-drying. Pulses can be divided in to two generals categories according to the difficulty faced in dehusking riz.

(i) hard to dehusk pulses namely arhar, urad and moong and

(ii) easy to dehrsk pulses namely channa (Bengal gram), masoor (Lentil) and field pea.

In general, the cleaned and graded pulses are initially passed through the Roller mill (Roller Dehusker) to impart scratches, cracks and dents on its hard seed coat. This operation is termed as 'Pitting' . This facilitates the easy migration diffusion of oil and water in between the husk and cotyledons which in turn weakens the gum bonding and thus loosens the husk adhering to the cotyledon. The pitted pulse grains are passed through the sieve cleaner to separate out the splits, husk and powder and later smeared with oil at the rate of 100-500 gram per quintal manuallyor with auger mixer. At the end of storage period, water is applied to the grains at the rate of 1-5 kg/q and stored for 12-14 h (overnight) and later sun-dried for 1-3 days before subjecting to milling.

5.0.2.1.8. **Dehusking:** Pulse grains are subjected to dehusking in Roller Dehuskers. Its roller is coated with carborandum. The carborandum number varies for different pulses. However, there is no standard fixed for any pulse grains.

The Roller used In this machine are of two types, viz. cylindrical and tapered. In case of tapered rollers, foundation is perfectly horizontal. The diameter of roller increase from feeding side to discharge side. This is done to increase pressure gradually on the pulse grains which helps in gradual dehusking.

To remove the-husk with minimum scourage of cotyledon, the conditioned pulse grains are subjected to mild abrasion inside the roller machine, removing 10-25% of husk in one pass. Some of the cotyledon mass is also scoured resulting in loss of dal yield. After passing the grain lot once or twice through the roller machine, the shelled husk, cotyledon powder, brokens and splits are separated out by Air-screen cleaners.

5.0.2.1.9. **Splitting:** This operation comprises of two steps namely loosening the bond between the cotyledons and splitting. For loosening of bond between the two cotyledons, water at the rate of 1-5 kg/quintal is applied to dehusked pulse grain (gota) and is stored for 2-12 hours and later sun-dried for 4-8 hours. At this stage, gota when hit against hard surface, splits in two, thus giving an indication that the lot is ready for splitting.

As such in this operation, there is no significant loss of cotyledons mass. However the embryo attached to two cotyledons breaks away, thereby, causing a loss in dal recovery by 1.5 to 2%.

5.0.2.1.10. **Polishing:** This is the last operation before packaging. In this operation, dal is imparted with a glazing appearance to improve its consumer's acceptance and market value. Depending upon the need, different materials like water, oil, soapstone powder and' SELKHARI' powder are applied to dal surface. In some cases, removal of sticking powder from dal surface is considered sufficient to improve its surface glaze.

a) Removal of Powder Dust: Cylindrical rollers mounted with the rubber mats or leather strips or cylindrical tapered emery rollers are used for the purpose. The dust particles sticking to dal surface are removed by gentle rubbing action on the roller surface. The speed and size of rolls is similar to Dehusking roller machines.

b) Water Polish: This is used for urad, chana, masoor and arhar. In this 1- 1.5kg of water per quintal of dal is applied while passing it through anyone of the polishers mentioned above.

c) Buff Polish: In this 2-2.5 kg of water along with 200-250g of oil per quintal of dal is applied with above polishers. This type of dal is preferred in Madhya Pradesh, Uttar Pradesh, Bihar, Maharashtra and Delhi.

d) Nylon Polish: In this, soapstone powder or 'selkhari' powder (1-1.5 kg/q) is applied to the surface along with water (1-1.5 kg/q) by passing through the polishing machine. In west Bengal, a set of screw conveyors arranged in a battery for repeated rubbings is used. The flights and shafts are covered with nylon rope to impart gentle rubbing. This is used mainly for masoor, moong, tur and urad. In Agra, field peas (without milling) are given polish with' selkhari 'powder (1.0-1.5 kg/q) by passing through Rubber Roll polisher. For polishing field peas, it is first cleaned and graded. The bigger size peas (60-65%) are subjected to powder polish while the smaller sized peas (35-40%) are split. In South India, similar polishing is given to whole moong and urad.

e) Teliya Dal: 2.5 to 3.0 kg of castor oil is mixed per quintal of arhar dal to make it look glossy. This is known as Teliya and is considered to be popular in Gujarat. The storage life of this dal is short.

5.0.2.2. BY PRODUCTS OF PULSES:

5.0.2.2.1. BESAN MANUFACTURE

Besan is made from chana dal (Bengal gram). It's production involvesthree major steps namely size reduction, sieving and packaging. Besan is made in rural areas and at home scale level in burr mills (atta chakki). Here, chana is ground to flour but size grading is not done. Capacities of such machines vary in between 50-100 kg per hour.

5.0.2.2.2. PUFFING OF PULSES:

Puffing and toasting of pulses is practiced all over the country. These products are traditionally used as snacks. It makes delighter with porous structure making it soft to eat. The increase in size is 1.5 to 2 times of its original size. Bengal gram and peas are best suitable for puffing. The grains are first soaked in water for short duration (1-3 minutes), mixed with sand heated to 250"C and toasted for 15-25 seconds with agitation. After sieving off the sand, the grains are dehusked between a hot plate and a fast rotating rough roller. The yield of puffed product is about 65-70% by weight.

5.0.2.2.3. PAPAD MANUFACTURE:

As you know Papad is a thin round rolled sheet of dried papad flour. Papad flour is made by combining few pulses flours like urad, moong etc. In some papad flours, gram pulse is also added. Rolling papad is generally a manual operation done by women folks. The papad flour along with spices like black pepper, jeera, soda and salt is tightly kneaded with water and thus rolled tightly on (Chakla- belan). A lady can roll about 2.5 to 4 kg of papad a day. CFTRI has developed a papad mill where kneaded papad flour is pressed in round thin sheet by keeping the dough in between two polyethylene sheets and placing it in between two parallel discs. One disc is pressed against other with the help of foot through a lever. This way 2 t03 inches papads are made. The capacity this machine is about 500 papad an hour.

5.0.2.3. Elimination of toxic factors.

To eliminate toxic factors from pulses, such as anti-nutrients and toxins, several methods can be employed. Here are some commonly used techniques:

1. Soaking: Soaking pulses in water for a specific period helps reduce anti-nutrients like phytic acid and tannins. Soak the pulses in water for several hours or overnight, and then discard the soaking water before cooking.
2. Sprouting: Sprouting pulses involves germinating them in a controlled environment. Sprouting breaks down anti-nutrients and increases the nutrient content of pulses. Rinse the pulses thoroughly, place them in a clean container, and cover with water. Leave them for a specific period, usually 1-3 days, until sprouts emerge. Rinse the sprouts well before consuming or cooking.
3. Fermentation: Fermenting pulses improves their digestibility and reduces anti-nutrients. Traditional fermented pulse products like tempeh and idli are examples of this method. Fermentation involves adding beneficial bacteria or yeast cultures to the pulses and allowing them to ferment for a certain duration.
4. Boiling: Boiling pulses in water is an effective method to remove toxins, such as lectins. Ensure you use a sufficient amount of water and cook the pulses until they become soft and tender. Discard the boiling water after cooking.
5. Roasting: Dry roasting pulses, especially in the case of certain legumes like chickpeas, can help reduce anti-nutrients and improve their taste. Roast the pulses in a pan or oven until they turn golden brown and have a crispy texture.
6. Combination methods: You can also use a combination of the above methods. For instance, you can soak pulses overnight, rinse them thoroughly, and then cook them using boiling or pressure cooking methods

5.2.0. INTRODUCTION OF PROCESSING METHODS FOR OILSEEDS:

Vegetable oil industry is one of the major industries in the world with a huge turnover next to petrochemicals. Vegetable oils not only play a significant role in nutrition but find uses in diverse applications. Vegetable oil is the only molecule which can be used as food, fuel and fabulous chemicals. In India itself, the turnover of this industry is about Rs. 70,000 crores with about Rs. 25,000 crores import-export trade.

Unfortunately, India's consumption of vegetable oils is more than its production and it is importing about 5 million tonnes of oils every year. With the technology upgradation, it is possible to enhance the production of the oil. Oilseeds and animals are the main source of fat. The largest source to oil is seeds of plants such as groundnut, rapeseed, mustard, sesamum, sunflower, soybean, castor seed and linseed.

Fats and oils are one of the five essential ingredients of human diet. Other ingredients are proteins, carbohydrates, minera!s and vitamins: In a balanced diet, oils and fats requirement per person per day is 35 g for vegetarians, 39 g for non vegetarian and 38 g for average diet. Oil basically acts as a store house of energy in a human body. Likewise, plants also store required food for their seedlings in the form of oil in their seeds. In other words, oil is used by the seedlings during germination and early growth

5.2.1. Processing of Oilseeds

Processing of oilseeds may vary with raw material however some general steps are common to all. The first step involves, preparation of the raw material; removal of fine impurities, husks or seed coats from the seeds and separating the seeds from the chaff. The seeds are then cracked to expose the "meats" of the raw material. Oil is then extracted mechanically with an oil press, an expeller. Presses range from small, hand-driven models that an individual can build to power-driven commercial presses. Expellers have a rotating screw inside a horizontal cylinder that is capped at one end. The screw forces the seeds or nuts through the cylinder, gradually increasing the pressure. The material is heated by friction and/or electric heaters. The oil escapes from the cylinder through small holes or slots, and the press cake emerges from the end of the cylinder. Oils can also be extracted with solvents, but solvent extraction is a complex operation and not suitable for small scale processor. After extraction oils are clarified to remove contaminants, such as fine pulp, water, and resins. Sealed glass or plastic bottles are adequate. Colored containers in a dark box help to increase shelf life. Seed cake is a valuable by-product of pressing and makes a good chicken, pig, or cattle feed. Oil finds wide uses as food, skin care products, aromatherapies, biodiesel fuels, and industrial lubricants.

5.1.5. **Structure of Oilseeds**

Oil seeds are mainly used for extraction of edible oil. Oilseeds crops grown in India are groundnut, rapseed, mustard, soybean, sunflower, sesame, castor, safflower, niger and linseed. Oilseeds are made up of three basic parts: the seed coat, the embryo, and one or more food storage structures. The seed contains two pieces of cotyledons that function as food reserve structures. The seed coat is marked with a *hilum* or seed scar. The basic function of the coat is to protect the embryo from fungi and bacterial infection.

Unlike seeds of grass family (e.g. wheat, rice, etc.), where oil is concentrated in a germ that lies along the side of the endosperm, the entire hull of oilseeds is the germ. It typically consists of a rootlet (hypocotyl) and two cotyledons leaves (Fig. 1.3) that are pushed above the soil and unfold during the germination. Oil in oilseed is distributed in spheresomes throughout the germ cells. Recovery of oil from oilseeds is facilitated by rupturing the cell walls by heat and pressure during flaking, and by optional extrusion, followed by pressing or solvent extraction. Waxes from the pericarp (hull), which protect the seed against drying are often also solubilized by the sovent or oil.

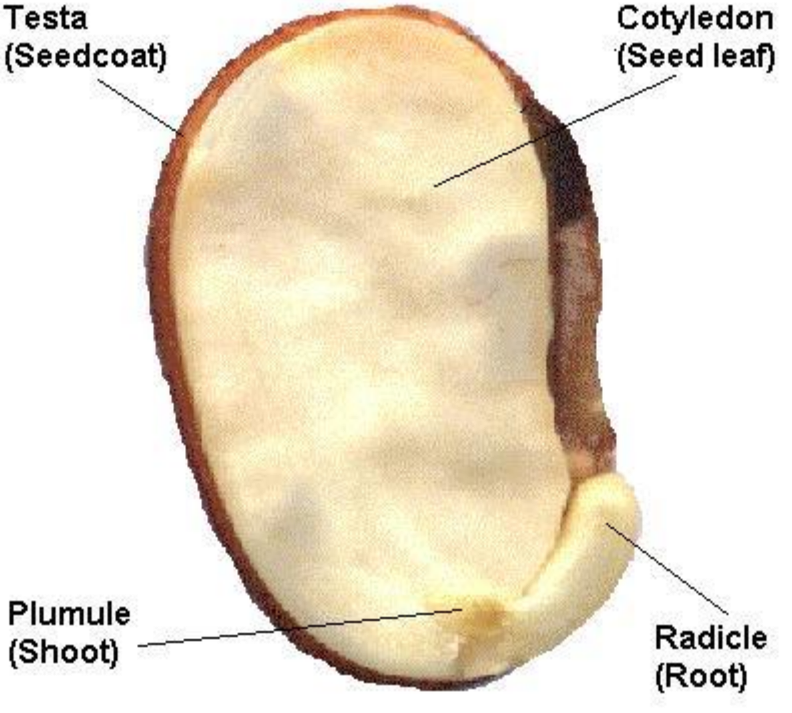

Fig 1.3 Structure of oilseed

5.1.6. Composition of Oilseeds

Proximate composition of various oilseeds grown in India is given in Table 1.3.

Table 1.3 Proximate composition of whole oilseeds (%)

Oilseed	Scientific name	Moisture	Protein	Fat, EE*	Crude fiber	Ash
Soybean (Whole seed)	*Glycine max*	10.0	36.3	18.9	5.0	4.4
Groundnut (Shelled kernel)	*Archis hypogea*	10.0	26.0	45.0	4.0	2.5
Corn germ (Dry milled)	*Zea mays*, L	10.0	13.0	22.5	4.5	2.5

Sunflower seed, oil-type (Whole seed)	*Helliathus annus*	10.0	21.0	42.0	19.0	4.5
Cotton seed (Cottonseed with linters)	*Gossypium hirsutum* L.	10.0	22.0	19.5	19.0	4.5
Rapeseed/Canola (Whole seed)	*Brassica juncea*	8.0	22.0	41.0	10.0	5.0

EE*- Ether extract

5.1.7. UNIT OPERATIONS FOR OIL EXTRACTION

For extraction of oil, the oilseeds have to undergo some or all of following unit operations:

5.1.5.1. Drying: Proper handling, drying and storage of oilseeds is important for their processing into quality products. The moisture control of oilseeds at the time of harvest is usually high and uncongenial for their safe storage. Thus, the oilseeds need to be dried prior to their storage. Sun drying is traditionally adopted. It is economical but has its limitations such as long time of drying, seeds remain exposed to insects, birds, atmospheric dust and unpredictable sun-shine. Due to these factors, mechanical drying is gaining popularity. In this method, hot air at 60-65°C is passed through oilseeds to remove moisture. The oilseeds should be dried at or below 10% moisture content for safe storage upto one year. If the oilseeds are to be stored as seeds, then it should be stored at or below 8% moisture content (wb).

5.1.5.2. Cleaning: This is an important operation. Here, the impurities like dust, stones, pebbles, stalk, brokens, damaged seeds, immature seeds, weed seeds and other seeds are to be removed for safe storage of oil seeds. Also, cleaned oilseeds fetch higher market price, The cleaning of oilseeds is generally done by sieving operation. For small quantity of seeds, generally hand sieves are employed. However, in oil mills, electric motor operated

5.1.5.3. Screen Air Cleaner-cum-Grader: This isthe machine which is most commonly used for cleaning and grading of oilseeds. Here, oilseeds are dropped on top screen. While falling down they confront high velocity air stream. The light impurities like dust, stalks etc. are carried away by this air stream and are deposited in air trough . . This air stream is created by an air aspirator fitted on top ofthe machine. The top screen has perforations larger than the size of the seeds. Thus, the seeds fall through this inclined vibrating sieve. The larger size impurities like stalk, dried leaves, husk, stones etc. pass over the screen and are collected on the tail end of the top screen. This operation where desired seeds pass through the screen is known as 'scalping operation'. The seeds and smaller impurities which pass through the top screen, fall on the upper end of the bottom screen (second screen). The perforation of this sieve is smaller than the size of the seeds. Due to this, seeds pass over the screen and are collected at it's tail end. The smaller size impurities pass through the discharge outlet. The operation where the desired seeds pass over the screen while smaller size impurities pass through is called' grading operation'. The screen used for this operation is called 'Grader'.

This way, oil seeds are cleaned and graded by 2 Screen Air Cleaner-cum Grader. When the oilseeds are to be stored for seed purpose, then sometime 3 screen air cleaner is used for cleaning and grading. Here, the top screen acts as scalper while the 2 nd and 3 rd screens act as graders.

5.1.5.4. Storage: As earlier explained, for safe storage of oil seeds, the moisture content and impurity free a seed is the pre-requisite. The seeds must be at or below 10% moisture content for safe storage. When the oil seeds are to be used for seed purpose, it should be at or below 8% moisture content (wet basis). The other important factor for safe storage is relative humidity. It should be below 65%, so that the moisture of oilseeds does not increase during storage.

Pre-Treatment Related to Oil Yield and Quality: For higher recovery and quality oil from oilseeds, it is necessary to subject the seeds under some pre treatments.

Following are the pre treatments which improve the oil yield and quality of oil.

5.1.5.5. Methods for Processing of Oilseeds.

i) Cleaning: As earlier described in cleaning operation, all the impurities and undesirable seeds are removed. This way, the quality of oil recovered from clean seeds is better.

ii) DehuUing: The hulls of oilseeds are fibrous and have low oil content. Dehulling of oilseeds is advantageous as the hulls reduce the total yield and capacity of oil extraction equipment’s.

ill) Size Reduction and Flaking: The oil in oilseeds is packed inside cells. These cells should be ruptured before subjecting to oil expression. The oil expression can also become easier if the wall of the cell is made permeable. For this, some of the following operations are adopted.

• **Size Reduction of Oil seeds by Grinding:** The oilseeds can be ground to smaller size particles by attrition mill, hammer mill, roller mill or corrugated cracking rolls.

• **Heat Treatment:** Almost all the oilseeds yield oil easily ifheated before oil expression. The heat treatment also known as 'cooking' weakens the cell walls. It also causes volumetric expansion of oil droplets which result in the rapture of cell walls causing expulsion of oil. Generally, the time of cooking is between 30 to 120 min. at a temperature of 105-130oC. Certain amount ofmoisture inside oilseeds is essential to achieve the desirable heat effects. Generally 9-14.5% moisture of oilseeds is desirable.

There are two methods of oilextraction as under:

5.1.5.5.1. Mechanical oil expulsion methods

5.1.5.5.2. Solvent extraction methods

5.1.5.5.1. MECHANICAL OIL EXPULSION METHODS

Under Mechanical oil expulsion methods, it is the pressure which is used to expel out the oil from oil seeds and are thus also termed as 'Pressure Extraction methods' Following 4- types of Mechanical oil mills are in vogue: i) Ghani: In India, mostly oil is extracted by

i). Ghanis - The ghani consists of mortar and pestle. Here, the size reduction of seed is accomplished in the Ghani itself. The seeds placed inside the mortar are crushed by the constant movement of pestle under its weight and rough surface of mortar and pestle. About 4% water is added in oilseeds which helps in releasing oil during crushing. These Ghanis are either bullock operated or power operated. The recovery of oil in both types is less. However power Ghanis yield higher oil as compared to bullock operated Ghanis. In case of bullock operated ghanies, it takes about 3 hours to crush one charge of 16 kg mustard, producing cake with average oilcontent of 11-16%. In power ghanies, a batch of about 20 kg mustard seed takes about 40 minutes to be crushed, yielding cake with about 10-12% oil after two crushings. These cakes are used in Solvent extraction plants for further extraction of oil.

ii) Press Type Oil Expellers: Here, the oilseeds are generally heated inside to barrel and are then subjected to pressure by a plunger. The oil oozes out as the increasing pressure ruptures the cells bearing oil. It is a batch process. These days, in market, screw press type and hydraulic press type oil expellers are available. Generally, hydraulic presses are preferred over screw presses as they are easy to operate, provide more power and are efficient.

iii) Mechanical Screw Expellers: In this machine, the pressing is accomplished by means of a worm shaft continuously rotating within a cylindrical cage. Due to small opening of the orifice at the discharge end, a high pressure of the order of 1200-1500 kg/ern? is developed inside the annular space. This pressure burst the oil cells and helps oil to ooze out through the cage. This type of expeller ismore efficient than Ghani and Press type expellers. Here, the resulting oil cake contains 5-7% oil.

5.1.5.5.2. **SOLVENT OIL EXTRACTION METHODS**

This is the most efficient method of oil recovery from oil bearing materials. It is particularly advantageous for extraction of oil from low oil bearing materials like soybean, rice bran, mango kernels and oil cakes recovered from Mechanical expellers. Here, the oil bearing materials/oilseeds is made to dissolve in solvent. Later, oil isseparated out from the solvent through distillation process. By this process, more than 99% oil is removed. Here, the solvent which is widely used isfood grade n-hexane, with a boiling temperature range of64-70°C. The solvent extraction plants are either batch or continuous type. However, the continuous type solvent extraction plants are more popular because of its higher efficiency.

Soybeans are subjected to preliminary cleaning and milling operations as usual. The soy meal is then cooked. The cooking of meal by heat treatment is done under mild conditions. The heat treated meals are then converted into flakes using smooth flaking rolls. Solvent extraction of cooked flakes can be done batch-wise or continuously. In Continuous Extraction method, counter current solvent is preferred. The oil from miscella is separated by distillation and stripping under vacuum. The extracted meal is desolventized by heating with live steam in a desolventizer. The solvent from the distillation and stripping columns as well as from the desolventizer is condensed, recovered and stored in the solvent storage tank. The oil, separated from miscella in the distillation column goes to oil stc.age tank after cooling. The de-oiled cake contains about 1% residual oil.

5.1.5.8. **REFINING OF EDIBLE OILS**

According to PFA specifications, refmed vegetable oil is a vegetable oil obtained by expression, neutralized with alkali, bleached with absorbent earth and/or by activated carbon, and deodourised with steam. No other chemical agent should be used. The name of the vegetable oil from which the refined oil has been manufactured should be clearly specified on the label of the container. Refined oils should not contain more than 0.25% free fatty acids and 0.10% moisture by weight. In addition, they should also conform to the standards prescribed for the edible oils from which they have been prepared. Although not specified, the refined oils should have as light a colour as possible; be odourless: neutral to taste; and should have good keeping quality.

Generally, refined oils are free from moisture and enzyme activity. The deterioration in refined oils is either due to rancidity or flavour reversion. The latter may be caused by the action of even an extremely small amount of oxygen. The crude oil is refined to convert it into edible grade oil. The oil is first passed through filter press to remove the seed material present in crude oil. Different methods are adopted to remove other impurities present in the oil. For example in crude cotton seed oil, free fatty acids are neutralized by adding caustic soda (NaOH) or soda ash. Here soaps are formed which are known as alkalifoods. The soaps are removed from oil by centrifuges and filters. The neutral oil is washed twice or thrice by water to wash out the remaining soap in the oil. The waste water is separated by filters and centrifuges.

The oils are then decolorized with the help of the adsorbent like activated carbon and or activated clay at a high temperature by a batch process or by a continuous process. The bleached oil is then deodorized by heating the oil with super heated steam under high vacuum. For the manufacture of salad oil, bleached oil is subjected to winterization which consists of cooling the oil to a low temperature for a long time and filtering the solid materials from the oil.

5.1.5.9. BY PRODUCTS OF OIL PROCESSING

Here are some common byproducts of oilseeds:

1. **Oilcake or Meal:** Oilcake or meal refers to the solid residue left after the oil is extracted from the seeds. It is a valuable byproduct and is commonly used as animal feed due to its high protein content. Oilcakes can also be used in the production of biofuels, fertilizers, and food additives.
2. **Oil:** The primary product of oilseeds is oil, which is extracted through processes such as pressing or solvent extraction. The extracted oil can be

further refined for various applications, including cooking oil, industrial lubricants, biodiesel production, and cosmetic products.

3. **Husks and Shells:** Many oilseeds have husks or shells that surround the seeds. These husks and shells are often separated during the oil extraction process. They can be utilized as biomass fuel for energy generation, animal bedding, or as raw materials for the production of activated carbon.
4. **Lecithin:** Lecithin is a natural emulsifying agent derived from oilseeds, particularly soybeans. It is a byproduct of the oil extraction process and has various applications in food processing, pharmaceuticals, cosmetics, and industrial manufacturing.
5. **Gums:** Some oilseeds, such as guar and locust bean, contain gums that are extracted during the oil extraction process. These gums have thickening and stabilizing properties and are used in various industries, including food, pharmaceuticals, and textiles.
6. **Residues:** Depending on the oilseed and extraction method, there may be other residues or byproducts generated, such as seed coats, fibrous materials, or impurities. These residues can be utilized for different purposes, such as animal feed, composting, or even in the production of specialized products like fiberboards.

5.1.6. CONCLUSION:

In this unit, we have learnt about the methods of pulses milling viz. wet and dry method. In dry method, it is the oil which loosens husk while in wet method, it is water which dilutes gum in between husk and kernel which makes it easy to dehusk pulses. In wet method, the cooking quality of dal is affected. Due to this, the dry method of milling is mostly practiced in country. In general, pulse milling is done in three steps namely loosening of husk, dehusking and splitting of pulses. To improve the market value of dal, it is polished by various methods.Besan a product of chana dal is manufactured by hammer mill. Puffing of pulses is done to make it soft to eat. It is done by water conditioning and roasting the pulses. In present days, papad is being manufactured at industrial level. In this, papad flour along with required spices is kneaded with electric motor operated kneading machine. The rolling of dough is done manually by female workers including other operations like sun drying and stalking. The weighing and packaging is later done in industry premises. For papad rolling, two machines are also available viz. Press type and Rollins type papad machine.

Oil seeds and animals are the main source of fat. The largest source to oil is seeds of plants such as groundnut, rapeseed, mustard, sesamum, sunflower, soybean, castor seed and linseed. There are two methods of oil extractions namely Mechanical and Solvent extraction. In mechanical method, it is the pressure of various types which is used to crush the oilcells and extract out the oil. In solvent extraction method, oil of oil bearing material is made to dissolve in solvents and later solvents are vaporized to separate out the oil. After extraction, the crude oils are refined to make them edible grade. The deoiled cake is generally used as animal feed. However, this cake is rich in protein and thus is used for human consumption too. However, for this, the oilseeds must be made free from crude fibre by removing hulls before oil extraction. These deoiled cakes can also be used as defatted flour for human consumption. In this unit, we have learnt about the types of oil seeds, the major and minor ones along with their average oil contents. We also learnt about methods of oil expulsion

EXERCISE:

7. Classify the legumes on the basis of type of stored energy.

8. What are the limitations in use of soybean as a food legume?

9. Describe different types of carbohydrates found in pulses.

10. Name anti-nutritional factors present in pulses.

11. Name two essential amino acids lacking in legumes.

12. What do you mean by pulse milling?

13. Describe dehusking of pulse.

14. What is the byproduct of pulse milling, and its use?

15. What role does oil play in a human body and seeds?

16. What are the main sources of oil?

17. State the types of oil seeds and name the major sources of oil.

18. Name the methods of oil extraction.

19. Name the unit operations for extraction of oil.

20. Define the process of refining of oil

GLOSSARY

Food : Food is any substance, primarily composed of carbohydrates, fats, water and/or proteins, that can be eaten or drunk by an animal or human being for nutrition or pleasure.

Caryopsis : The cereal grain is one seeded indehiscent fruit called caryopsis. In this the pericarp is completely fused with the seed coat.

Hulling : The process of removing an unpalatable husk or shell around the cereal grain.

Anti-nutritional Factor: Some compounds found in pulses that reduce their biological value.

Milling : The conversion of grain into flour.

Parboiling :A primary treatment given to rice to improve its keeping quality and nutritional value. Parboiling involves soaking and heating the rice which pre-cooks the grains, loosens the hull, sterilizes and preserves the rice.

Gluten :A protein found in wheat.

Puffing : The process of making a puffed ready-to-eat product from rice.

Flaked Rice :A popular breakfast cereal known as '*poha*' from rice. The process involves rolling the conditioned rice to fracture the outer cells.

Plasticity :A unique property of oils, wherein oils gradually soften on heating, because they do not have a sharp

melting point.

Hexane an oil solvent

Deoiled cake the mass of oilseed after separation of oil.

Defatted flour the flour made from deoiled cake.

Bal-ahar a nutritious product made from deoiled cake of groundnut.

Refined oil the oil free from natural impurities like free fatty acids, colours and odour.

Meal deoiled cake

Ghani: a traditional machine used for oil expression.

Scalper: a screen or sieve with higher size perforations than desired

Grader a screen or sieve with perforations smaller than desired seed so that the desired seeds pass over the screen while smaller size undesirable material/impurities fall through the screen

REFERENCES

- B. Sivasankar. (2004). Food Processing and Preservation Prentice-Hall of India Pvt. Ltd
- Desrosier, N.W. (1963). The Technology of Food Preservation, AVI Publications.
- Eckles & Eckles. (1991). Technology of Milk & Milk Products, AVI Publications.
- Gaurav Tewari (Ed) and Vijay Juneja (Ed). (2001). Advances in Thermal and Non-Thermal Food Preservation; ARS, USDA.

- Gustavo V. Barbosa-Canovas (Ed), Grahame W. Gould (Ed). (2000). Innovations in Food Processing (Food Preservation Technology Series) : CRC Publishers
- Mahindru, S.N., (2000). Food Additives; Published by Tata McGraw Hill.
- Ramaswamy, H.S. & Michele Marcott. (2005). Food Processing – Principles & Applications; CRC Publications

Unit-VI:FRUITS AND VEGETABLES PROCESSING

Unit-VI: FRUITS AND VEGETABLES PROCESSING

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6.18. FUTURE THRUST

6.19. CONCLUSION

OBJECTIVES:

By the time you have studied this unit, you should be able to:

- prepare various fruit beverages;
- learn principles of various preservation techniques;
- know equipment used in the processing of fruit beverages;
- explain quality aspects and standards of product; and
- describe packaging requirements and types of packaging material.

Unit-VI: FRUITS AND VEGETABLES PROCESSING

6.0. Introduction

Fruits and Vegetables play a significant role in our daily lives. They are known as protective foods since they are high in minerals and vitamins. Indian agriculture is the country's economic backbone. One of the biggest producers of fruits and vegetables is India. In every country, veggies are quite important to the local economy.

India has a great possibility to manufacture everything because of its geography and geographic location. The year-round availability of fruits and vegetables, however, encourages a passivity towards their commercial processing. Also poorly accepted by the populace are processed foods. This frequently resulted in overproduction, increased post-harvest losses, and a decrease in the economic impact of processed goods.

6.1. Structure,

The word for the fruit is "fructose" in Latin, which also means to enjoy or to generate. The fruit, which is an ovary that has matured, is the result of fertilisation. Fruits are broken down into the following categories: pome (apple and pears), stone (mango, peach, plum, cherry), berry (strawberry, tomato), nut (walnut, cashewnut), hesperidium (citrus), synconium (fig), sorosis (mulberry), coenocarp (jack fruit), and syncarp (custard apple). The crops grow from a range of plant parts, including potatoes, peas, and cabbage. According to the plant parts that are used to make vegetables, they are divided into the following categories: fruits (gourds, brinjal, and capsicum); stems (asparagus, amaranths); leaves (cabbage, lettuce, spinach); flowers (broccoli, cauliflower); and underground portions (radish, carrot, potato, onion, and garlic).

Fruits are also divided into climacteric and non-climacteric categories for processing or storage. The climacteric fruits are those that completely senesce after being harvested and while being stored. Apple, banana, ber, fig, guava, mango, pear, peach, papaya, sapota, and tomato are just a few examples. Nonclimacteric fruits, such as citrus, grape, litchi, pineapple, pomegranate, strawberry, etc., ripen on the plants. During the ripening process, climacteric fruits produce more ethylene and carbon dioxide at a higher rate than nonclimacteric fruits. It causes some chemical changes as well as alterations in texture, colour, and flavour.

6.2. Composition:

You are aware that fruits and vegetables are considered to be nourishing foods because they are a significant source of vitamins and minerals. The variety, pre-harvest procedures, and maturity all affect the quantity and quality of these nutrients. These nutrients contribute to the colour, flavour, and texture of the food. Fruits' colour is mostly caused by sugar-derived anthocynidins. The ratio of sugars to acids determines the flavour of the fruits. In addition, there are several volatile flavouring substances. Polysaccharides control how the fruits' texture is determined. Fruits contain phenolic chemicals as well. Astringency, bitterness, and fragrance are imparted; these qualities offer resistance to infections and stress.

6.3**. PHYSIOLOGY OF FRUITS AND VEGETABLES**

Fruits and vegetables are harvested when they reach physiological maturity, which allows for some marketing time flexibility and helps the food reach a desired eating quality when it reaches the consumer. Produce that has been harvested before it has reached physiological maturity lacks flavour and loses moisture quickly. If harvested too late, the fruit may be overripe and have a very brief shelf life. Fruits and vegetables can now be evaluated for maturity using both objective and subjective procedures that have been standardised. They fit in the category of:

- **a. Physical methods**
- **b. Chemical methods**
- **c. Biochemical methods**

One of the most consumed types of beverages worldwide is fruit-based drinks and beverages. Compared to the majority of artificial and aerated drinks, fruit beverages and drinks are far easier to digest, extremely refreshing, thirst-quenching, appetising, and nutritionally far superior. Fruit-based beverages and drinks have seen a sharp rise in popularity in recent years. These goods are made using fruit juices or pulp that has undergone minimum processing such filtering, clarifying, and pasteurisation. To create beverages and drinks, the fruit juice or pulp is combined with components such as sugar, acid, stabilisers, vitamins, and preservatives.

6.4. Fruit-based beverages

The following list includes numerous subcategories of beverages and drinks made with fruit juice or pulp.

The category of non-alcoholic and non-carbonated beverages includes natural fruit juices, sweetened juices, ready-to-serve beverages, nectar, cordial, squash, crush, syrup, fruit juice concentrate, and fruit juice powder. The following are the main categories of fruit beverages:

- 6.4.1. Ready-to-Serve (RTS) pre-packaged Beverages
- 6.4.2. Fruit juice and Nectars
- 6.4.3. Dilutable beverages

6.4.1. Ready-to-Serve (RTS) Beverages

The ready-to-serve beverages as per FSSA specifications should contain at least 10 percent fruit content and not less than 10 percent TSS besides 0.3% acid maximum as citric acid. The levels of permitted preservatives include 70 ppm (maximum) for sulphur dioxide and 120 ppm (maximum) for benzoic acid. The total plate count and yeast and mold counts should not exceed, to 50.0 cfu/ml and 2.0 cfu/ml, respectively. The Coliform counts should be nil in 100 ml beverage samples.

These drinks are referred to as ready-to-serve beverages since they are consumed straight up without being diluted. This category includes the bulk of packaged fruit beverages. For RTS beverages, a wide variety of fruits are preferred, including mango, citrus fruits, berries, litchi, guava, pineapple, and grapes. Juice or pulp is mixed with water, the necessary amount of sugar, acid, stabiliser, colouring, and flavouring additives, and then filtered if needed. The RTS mix is instantly cooled after being pasteurised (80-900C) in a bottle for 20 to 30 minutes and in a continuous juice pasteurizer for a few seconds to a minute. Because UHT processing of RTS beverages has a longer shelf life and results in less nutritional loss during processing, it is becoming increasingly popular nowadays.

Depending on the fruit and cost-effectiveness, different amounts of fruit juice or pulp may be used. Antioxidants like ascorbic acid are frequently added to RTS beverages because the presence of oxygen in headspace frequently causes oxidation, which results in an off-flavor and a loss of nutritional content. In addition to it, substances for colour and flavour that are resistant to heat and oxygen are desirable.

6.4.2.1. Natural fruit juice

Juices made from natural fruit are also considered RTS beverages. It can be characterised as pure juice that is extracted from mature, ripe fruits and contains only fruit. The juice is extracted using a variety of techniques and mostly consists of sugars, acids, vitamins, minerals, and other ancillary elements. Thermal processing and freezing are used to preserve them. Fruit juices like apple, pineapple, citrus, grapes, pomegranate, and mango are frequently available.

The sweetened juices are liquids that include at least 85% juice and 10% TSS. To raise the TSS concentration and balance the acid-to-sugar ratio, sugar and acids are introduced. For this, a variety of fruit juices are used. Sometimes two or more juices are combined to create a tasty, energising beverage with improved flavour and nutritional balance. These drinks are also referred to as fruit punch. To balance the acidity and reduce flavour variations, juices from some fruits are blended or mixed. To make uniformly high-quality products on a commercial scale, fruit juice concentrate is typically utilised in combination with a sufficient water dilutionAn example might be a fruit that is both extremely sweet (grape) and bitter (grapefruit); highly acidic (lime, lemon, sour cherry); and bland-tasting (pear, apple).

Highly flavoured (guava, banana) with bland & insipid tasting fruits (pear, loquat)

In order to prevent spoiling, freshly squeezed juices must be kept in storage at 0 to 50 degrees Celsius. Some of them might have low pH levels (below 4.5), thus to assure commercial sterility, they must be thermally processed for a short time at temperatures between 85 and 950 C. The FSSA has established the minimal TSS and acidity for a variety of natural fruit juices.

6.4.2.2.Nectar

Nectar is made by combining sugar, acid, and other components with the pulp of tropical fruits like mango, litchi, guava, papaya, citrus fruits, and pineapple. According to FSSA criteria, nectar must have a TSS of at least 15 o Brix and at least 20% fruit content, with the exception of pineapple and citrus fruits, where fruit content must be at least 40%. You can utilise fruit pulp, puree, juice, or concentrate as a starting ingredient. More than 3.5% of the nectar's acidity should be in the form of anhydrous citric acid. Sorbic acid at 50 ppm is the maximum permitted level of preservative in nectar. The sodium or potassium salt of sorbic acid is used to add the sorbic acid. Additionally, nectar isn't diluted before being consumed. Nectar also has a thick texture and a hazy look. Because polysaccharides like pectin, cellulose, hemicellulose, and starch are present, nectar and other liquids are cloudy. Due to pectin methyl esterase (PME) activity, citrus juices in particular lose their cloudiness., which induce the pectin molecule to de-esterify, settling down and losing its cloudiness. In order to deactivate the PME, citrus juices or concentrates must be thermally processed. Hydrocolloids are occasionally included to stabilise the cloudiness. Nectar is preserved in a manner similar to that described for RTS beverages.By performing any required processing activity, the short shelf life of nectar (a few days at refrigerator temperature) could be overcome.

6.4.2.2.1. Flash pasteurization

In a plate-type pasteurizer equipped with a heat recovery and cooling device, nectar can be pasteurised. For the majority of products, a temperature in the range of 85-950C for 15 to 60 seconds is utilised; however, this again depends on the type of juice and the initial microbial load. Products that need to be inactivated by both enzymes and microorganisms are heated to a slightly higher temperature (90-950C) for no longer than 15 seconds. For slightly viscous nectars, a tubular pasteurizer is preferred. Pasteurizer and aseptic packaging equipment are connected during aseptic packing operations, either directly or through an aseptic buffer tank.

6.4.2.2.2. In-pack pasteurization

On small scale units, in-pack pasteurisation is the most popular procedure. The juice is packaged—mostly in bottles—and submerged in heated water tanks maintained at a temperature of 80 to 900°C. To make sure the product is safe, pasteurisation is done at temperatures between 80 and 850 C for up to 20 minutes. After being air dried, the treated bottles are labelled. The product must be processed at the intended temperature and the pack must be securely sealed.

6.4.2.2.3. Hot fill operation

A more convenient way to guarantee the nectars' microbiological integrity is through hot filling. The bulk product is heated to a predetermined temperature before being packed hot (between 70 and 850 degrees Celsius) and sealed right away. They should be pre-heated in the case of glass bottles to reduce thermal shock. The packs are held at the right temperature for the required amount of time while being properly inverted to mix the nectar. They are then air dried and labelled after being chilled in a hydro-cooler to 250C.

6.9.3. Dilutable Beverages

Drinks that can be diluted with appropriate diluents, such as water, alcoholic beverages, or milk, can be consumed. Such beverages are made using a method that is relatively similar to that used to make syrup for fizzy beverages. These products have a number of benefits, such as the flexibility to employ varied syrup to water ratios, bulk reduction, the use of extra and flavourless fruits, and innovative formulation improvements. Table-6.1 lists the different components and how they are used to make dilutable drinks. Figure 6.1 shows theprocess flow diagram for producing dilutable beverages.

Table 27.1 Ingredients used in dilutable beverages

S. No.	Ingredient	Remark
1	**Fruit Components**	Added in the form of fruit juice or pulp or comminute (whole fruit preparation), required amount should be more than 25%. For uniformity concentrated fruit juice or pulp or comminute of standard degree brix is used. Source of fruit sugar, acid, pectin, colouring pigments, flavouring compounds and micronutrients.
2	**Syrup**	Carbohydrate syrup is added in various forms like sucrose, invert syrup, glucose syrup or modified syrup. Provide body, impart sweetness; assist in development of flavour, mild preservative effect. Always added after filtration and sterization.
3	**Acid**	Citric acid is most preferred acidulant, other that may be used are malic, lactic and tartaric. Balance acid to sugar ratio, anti-microbial. Impart flavour as well.
4	**Preservatives**	Mainly added to prevent growth of fungi, yeast, lactic acid bacteria. Permitted are sulphur dioxide, benzoic acid and sorbic acid.
5	**Flavourings**	Mostly natural or natural identical flavourings are used. Must improve the flavour of beverages without affecting other properties.
6	**Colourings**	A permitted food colour that may enhance the aesthetic appeal of the beverage is used. It may include natural, natural identical or synthetic dyes. Maximum permissible limit is 100 ppm for coal tar dyes.
7	**Other Additives**	It may include stabilizers to keep the fruit solids in suspension and improve mouthfeel of the beverage. Acidity regulators, emulsifiers, anti-oxidants and clouding agents are also used to enhance the acceptability of these beverages.

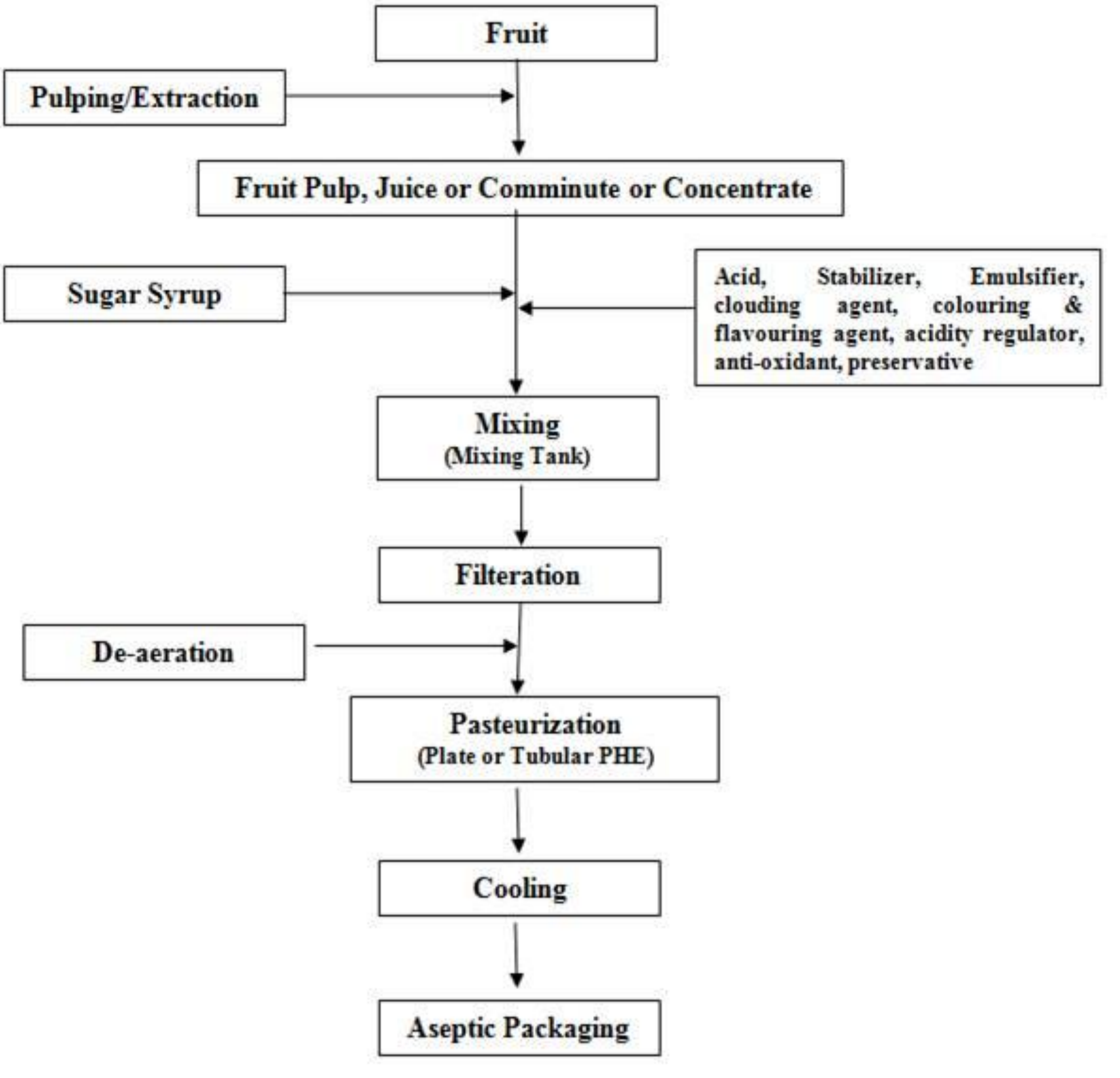


Fig. 27.1 Process flow diagram for the manufacture of dilutable beverages

Here we will cover two popular goods that fall under the category of dilutable beverages.

6.10. Cordial

Fruit juice cordial is a sparkling, clear fruit beverage that has been sweetened and in which all pulp and other suspended materials have been totally removed. Clarified fruit juice, sugar syrup, acid, and other substances are combined to make cordial. According to FSSA specifications, cordial must have a TSS concentration of at least 300Brix and a minimum fruit content of 25%.More than 3.5% of the cordial's acidity should be in the form of anhydrous citric acid. 350 ppm of sulphur dioxide or less is the maximum permitted amount of preservative in cordial. 600 ppm of benzoic acid. For preparing cordial, citrus juices like lime and lemon are preferred. Typically, the cordial is consumed after being blended with alcoholic beverages like gin.

Fruit juices may either be treated with commercial enzyme preparations like pectinase to hydrolyze pectin or they may be kept for a longer period of time to eliminate suspended particles and pectinous components. The juice that has been clarified is used to make cordials.

6.11. Squashes and crushes

Squash is the product, which is prepared by mixing of calculated quantity of fruit juice or pulp, with sugar, acid and other ingredients. As per FSSA specifications, squash should contain not less than 25 per cent fruit content in finished product and the total soluble solids content should not be less than 40^0Brix. The acidity of the squash should not be more than 3.5 per cent as anhydrous citric acid. Mango, orange, lemon, pineapples, grape and litchi are used for making squash commercially. Squash can also be prepared from lemon, bael, guava, pear, apricot, muskmelon, papaya, passion fruit, peach, plum, mulberry, raspberry, strawberry, grapefruit, etc. The maximum permissible limit of preservative in squash is 350 ppm of sulphur dioxide or 600 ppm of benzoic acid. Potassium metabisulphite is not added in dark coloured fruits as it may bleach the anthocyanin pigments. In such beverages sodium benzoate is used.

Commercially available squash contain 40 to 50 percent sugar and around 1.0 percent acid. They are diluted in the ratio of 1:4 before consumption. There is another category of dilutable beverage called crush. As per FSSA guidelines, crush must contain not less than 25 percent fruit content and 55 percent TSS. Mostly, the comminutes of citrus fruits and pineapple are used for crush manufacture.

Syrup is a type of fruit beverage that contains at least 25 percent fruit juice or pulp and not less than 65 percent TSS. It also contains 1.25-1.5 percent acid and diluted before consumption. The syrups from rose petals, almond, mint, khus, sandal and kewra are quite popular.

6.12. Ripeness and maturity,

when applied to fruit and vegetables, are often difficult to define. They usually are used for defining the appropriate state for harvesting and for eating. Fruit ripening is a highly co-ordinated, genetically programmed irreversible phenomenon which lead to the development of a soft and edible ripe fruit with desirable quality attributes via series of physiological, biochemical, and organoleptic changes. Ripeness is usually considered readiness for harvest. It is the result of a complex of changes many of them probably occurring independently of one another. Ripening marks the completion of development of a fruit and the commencement of senescence. Development and maturation of fruit are completed only when it is attached to the plant but ripening and senescence may proceed on or off the plant. Fruits are generally harvested either when mature or when ripe, although some may be consumed as vegetables may be harvested even before maturation has commenced. e. g.

zucchini. In vegetables, ripening stage does not occur and they are harvested over a wide range of physiological ages. As a result it is more difficult to differentiate change from maturation to senescence in vegetables. During the ripening process there is change in respiration rate and biosynthesis and evolution of ripening hormone ethylene. Based on their respiratory pattern and ethylene biosynthesis during ripening, harvested fruits can be further classified as climacteric and non-climacteric type. Climacteric is defined as a period in the ontogeny of fruit during which a series of biochemical changes are initiated by autocatalytic production of ethylene making the change from growth to senescence and involving an increase in respiration leading to ripening of fruit. This phenomenon was first observed by Kidd and West in 1925.

6.7.1. Climacteric fruits: These are harvested at full maturity, can be ripened off the parent plant. These produce much larger quantities of ethylene in association with their ripening, and exposure to ethylene treatment will result in faster and more uniform ripening. The respiration rate is minimum at maturity and remains rather constant, even after the harvest. The rate will rise up abruptly to the climacteric peak only when ripening is about to take place, and then it will slowly decline. Fruit softening, colour changes, development of taste and flavour and a number of other parameters of ripening process are associated with the climacteric cycle.

6.7.2. Non-climacteric fruits: These are not capable of continuing their ripening process, once they are detached from the parent plant. Also, these fruits produce a very small quantity of endogenous ethylene, and do not respond to external ethylene treatment. Non-climacteric fruits show comparatively low profile and a gradual decline in their respiration pattern and ethylene production, throughout the ripening process. This division is not fully conclusive and both types may also be found.

Table 1. Examples of Non-climacteric and Climacteric Fruits and Vegetables:

Climacteric	Non-climacteric
Apple, apricot, avocado, banana, fig, guava, kiwifruit, mango, melon, papaya, passion fruit, peach, pear, plum, sapota, tomato	Cherry, strawberry, blueberry, raspberry, orange, grapefruit, lemon lime, mandarin, pineapple, litchi, fig, watermelon, pomegranate

6.13. ETHYLENE AND RIPENING

Ethylene is a fruit ripening hormone which in minute amounts can trigger many events of cell metabolism including initiation of ripening and senescence. It is produced by unripe fruit in minute quantities (0.01-0.05 parts per million of internal air space) but at the beginning of ripening there is a drastic rise in ethylene production thousand time greater than unripe fruits. Treatment of unripe climacteric fruits with low concentrations of ethylene induces the climacteric rise in respiration and the onset of ripening and also stimulates the fruit tissue to produce its own ethylene. Thus, if the external supply of ethylene is removed, the ripening process is not interrupted. In the non-climacteric fruits ethylene production does not rise with ripening but treatment of unripe fruit with ethylene stimulate an increase in respiration and promotes in some changes associated with ripening such as the rate of loss of green colour from the skin. However, it does not stimulate the citrus fruit tissue to produce its own supply of ethylene and thus, if the external supply of ethylene is removed, the rates of respiration and of loss of green colour return to their original levels. Ethylene does not play an important role in the maturation of most vegetables. Generally the gas is produced in small amounts throughout the life of the vegetable and there is no upsurge in production as it matures. In vegetables there are no abrupt breaks in the respiratory pattern. However, metabolic changes are noticed on treatment of vegetables with ethylene. i.e. the respiration rate of potatoes rises in the presence of small amounts of ethylene while carrots produce a bitter tasting compound isocoumarin.

6.8.1. Ethylene Biosynthesis

Ethylene is synthesized from methionine in three steps:

1. Conversion of methionine to S-adenosyl-L-methionine (SAM) which is catalyzed by the enzyme SAM synthetase

2. Formation of 1-aminocyclopropane-1-carboxylic acid (ACC) from SAM via ACC synthase (ACS) activity

3. The conversion of ACC to ethylene, which is catalysed by ACC oxidase (ACO).

At the onset of fruit ripening, expression of multiple ACC synthase genes are activated, resulting in increased production of ACC. In most cases, it is the ACC synthase activity, which determines the rate of ethylene biosynthesis.

6.8.2. Mode of action

Ethylene, acts in symphony with other plant hormones (auxins, gibberlins, kinins and abscissic acid) to exercise control over the fruit ripening process. The relationship of other plant hormones to ripening is as yet not clearly defined. Different fruits do have different level of ethylene production. Climacteric and non-climacteric fruit appear to differ in in control of ethylene synthesis. The biosynthesis of ethylene in climacteric fruit is said to be autocatalytic. Climacteric fruits exposed to propylene begin to synthesize ethylene in an autocatalytic manner; non-climacteric fruit show no such response. It has been proposed that two systems exist for the regulation of ethylene biosynthesis.

System 1: It is common to both climacteric and non-climacteric fruit and is responsible for both basal ethylene production and the ethylene produced when tissue is wounded. This system functions during normal growth and development and during stress responses. It corresponds to low ethylene production in the pre-climacteric period of climacteric fruit. This system is auto-inhibitory such that exogenous ethylene inhibits synthesis and inhibitors of ethylene action can stimulate ethylene production. However, external application of ethylene during ripening to non-climacteric fruit may hasten the process in some cases.

System 2: This system operates during floral senescence and fruit ripening. It refers to an auto-stimulated massive ethylene production, called ‘autocatalytic synthesis’ and is specific to climacteric fruit. The inhibitor of ethylene action inhibits ethylene production. Apart from stimulating the ripening of climacteric and some non-climacteric fruits ethylene is also causes synthesis of anthocyanins, degradation of chlorophyll (degreening), germination of seeds, formation of adventitious roots, abscission and senescence, flower initiation, and respiratory and phenyl propanoid metabolism.

6.13.3. Ethylene inhibitors

Chemicals that inhibit the synthesis of ethylene or its action are known as ethylene inhibitors. • Ethylene synthesis inhibitors: These compounds block the synthesis of ACC from SAM. e.g. aminoethoxyvinyl glycine, methoxyvinyl glycine, aminoacetic acid etc. • Ethylene action blockers: These directly inhibit the action of ethylene e.g. silver thiosulphate, carbon dioxide, nickel, cobalt, methylcyclopropane, norbornadiene etc.

6.14. CHANGES DURING RIPENING Fruit ripening involves many complex biochemical changes, including seed maturation, change in colour, abscission from the parent plant, texture softening, production of flavour volatiles, wax development on skin, tissue permeability and change in carbohydrate composition, organic acids and proteins. During ripening the composition of fruit is altered either due to formation of new compounds or degradation of others. Out of various biochemical and physical changes occurring, changes in flavour, colour and texture are of utmost importance, for the acceptability of the fruit.

6.0.1. **Colour Changes** Pigments are essential for the attractiveness of fruits and accumulate most often in the skin during the ripening process. Color is often the major criteria used by consumers to determine whether the fruit is ripe or unripe. As fruit matures and ripen, green colour decline and develops yellow, red or other colours due to the presence of accessory pigments, which are characteristic of the various cultivars.

• Formation of pigments: During ripening there is the development of the enzymes to catalyse the formation of pigments. The main pigments formed and accumulated are: β-carotene, xanthophyll esters, xanthophylls and lycopene. The anthocyanins are formed partially from acetic acid units and partially from the amino acid, phenylalanine. Carotenoids are terpenoids compounds and as such derive from acetyl CoA via the mevalonic acid pathway. The primary carotene produced is phytoene which is further metabolized to give other carotenoid pigments.

• Degradation of pigments: Climacteric fruits show rapid loss of green colour with attainment of optimum eating quality. Some non-climacteric fruits also exhibit a marked loss of green colour with attainment of optimum quality. The green colour loss is due to the degradation of chlorophyll structure. The main factors responsible for chlorophyll degradation are: pH changes (mainly due to leakage of organic acids form the vacuole), oxidative systems and enzyme chlorophyllase.

6.0.2. FLAVOUR CHANGES

Flavour of a fruit depends upon synthesis of various flavour compounds which are unique to each fruit. Several of these compounds are complex and a large proportion of compounds is volatile in nature and gives the particular flavour. These flavour compounds are present in very low amount and includes alcohols, aldehydes, esters and other chemical groups. In both climacteric and non-climacteric fruits, the most important aroma volatiles that increase during ripening are the esters.

6.0.2.1.Formation of flavour compounds:

(a). **Biosynthesis:** The increase in flavor and aroma during fruit ripening is attributed to the production of a complex mixture of volatile compounds and degradation of bitter principles, flavanoids, tannins, and related compounds. Bio-synthesis of volatile molecules is an intact fruit is a complicated process. The alcohols and aldehydes are generated after metabolism of their corresponding amino acid of oxo-sugar. Some of the flavour volatiles are synthesized via mevalonate/ isoprene pathway. Various organic acids also act as substrate for flavour manufacture. Some other important class of flavour compounds i.e. monoterpenes, sesquiterpenes are generated from amino acid, sugars and lipids. Natural plant volatiles, such as aliphatic esters, alcohols, acids and carbonyls are derived from fatty acid metabolism. Most unripe fruits, e.g. apples, bananas and strawberries, produce a variety of fatty acids which, during ripening, are converted into esters, ketones and alcohols via ß-oxidation.

(b). **Degradative reactions:** Some of the volatiles are produced upon disintegration of fruit/vegetable tissue i.e. the compounds responsible for the characteristic taste and flavour are not present in the intact cucumber but are formed by enzymic breakdown of the fatty acids of the cell membranes which are disrupted when the cucumber cells are cut or chewed. The tannins (secondary metabolite) and other phenolic compounds, present in fruits impart astringency. Small amount of astringency is essential to the taste of many fruits but the high levels found in unripe fruits make them unacceptable. During ripening the tannins, are either partially broken down or polymerised into products which are not astringent. The ripening induces the breakdown of carbohydrate polymers, by various carbohydrases and leads to near total conversion of starch to sugars. This has the dual effect of altering the taste and texture of the produce. The increase in sugar renders the fruit much sweeter and therefore more acceptable. However many exceptions are there. In oranges and grapefruits the acid content drops during ripening, while in lemons, there is an increase in acids. Synthesis of ascorbic acid also occurs in many fruits during ripening. Generally, the acidity decreases as organic acid are utilized in respiration of fruits. The ratio of sugar to acid and the absolute amounts of both sugar and acid are important in the flavour quality of many ripe fruit. The breakdown of polysaccharides by cellular enzymes not only gives the typical sweetness, but also precursors for many aromatic flavor compounds.

6.9.3. TEXTURE CHANGES

Textural change is the major event in fruit softening, and is the integral part of ripening, which is the result of enzymatic degradation of structural as well as storage polysaccharides. The process of textural softening is of commercial importance as it directly dictates fruit shelf life and consumer acceptability. Cell walls of fruit undergo a natural degradation during fruit ripening, reducing cell wall firmness and intercellular adhesion. This leads firstly to the attainment of a desirable eating texture and then, as senescence begins, to a loss of this desirable texture. Fruit texture is influenced by various factors like structural integrity of the primary cell wall and the middle lamella, accumulation of storage polysaccharides, and the turgor pressure generated within cells by osmosis. Change in turgor pressure, and degradation of cell wall polysaccharides and starch determine the extent of fruit softening. Cell wall polysaccharides that undergo modifications during ripening are pectin, cellulose, and hemicelluloses. Amylase activity increases to some extent during ripening of many fruits. Starch is almost completely hydrolyzed to free sugars, thus contributing to loosening of the cell structure and textural softening during ripening. Pectin is the key substances involved in the mechanical strength of the primary cell wall and middle lamellae and contributes to fruit texture. During ripening, softening of fruit is caused by the conversion of protopectin, the insoluble, high molecular weight parent pectin into soluble polyuronides. The solubilisation of pectin is followed depolymerisation and deesterification; These changes are accompanied by an extensive loss of neutral sugars and galacturonic acid, followed by solubilization of the remaining sugar residues and oligosaccharides. Pectin from ripe fruit exhibit a lower degree of esterification, molecular weight and decreased neutral sugar content compared to pectin from unripe fruits. Ultrastructural studies of ripened fruits have also shown that cell wall breakdown is accompanied by dissolution of middle lamella and gradual dissolution of fibrillar network of primary cell wall. A rapid rise in polygalactouronase enzyme occurs during ripening is responsible for solubilisation of pectin. The other enzymes involved in hydrolysis of pectin are: pectin methyl esterase, pectate lyase, pectin lyase, arabinanase and galactanase. Firmness is also related to the turgor properties of a tissue or organ. During fruit ripening, there is a decline in turgor which contributes to textural changes probably due partly to an accumulation of osmotic solutes in the cell wall space and partly to postharvest water loss from the ripening fruit. In citrus fruit, softening is mainly associated with change in turgor pressure. According to softening behaviour, fruits are divided in to two groups. These are: 1. Very soft fruits: These fruits are greatly softened after ripening and possess soft and melting texture. e. g. apricot, strawberry, peach, plum, kiwifruit, European pear and most berries. 2. Moderately soft fruits: These fruits are softened to little extent after ripening and have a crisp and fracturable texture. e.g. apple, quince, cranberry, Asian pear, bell pepper and watermelon. There exist no relationship between climacteric and non-climacteric status of fruit and its texture.

6.15.4. OTHER CHANGES

6.15.4.1. Change in protein

During the onset of ripening the actual concentration of protein increases but the protein has no role in imparting any effect to eating quality. Changes in nitrogenous constituents however indicate variations in metabolic activity during different growth phases. During the climacteric phase of many fruits, there is a decrease in free amino acids which often reflects an increase in protein synthesis. During senescence, the level of free amino acids increases reflecting a breakdown of enzymes and decreased metabolic activity.

6.15.4.2. Change in cellulose and hemicellulose:

Ripening causes apparent dissolution of cell wall fibrillar network in many fruits. There is often little change in the cellulose structure in fruits during ripening and the activity of enzymes does not correlate with softening changes that occurs. Ripening also involves degradation of hemicellulose. There is a decline in characteristic monomers of hemicelluloses viz. glucose, xylose, and mannose during ripening of fruits but that does not have a very drastic influence on the texture of the product.

6.15.4.3. Changes in lipid

Little is known about changes in the lipid fraction. There are speculations about shifts in composition and quantity of phospholipid fraction during ripening.

6.16. VEGETABLE PROCESSING

Potato Processing- Rawmaterial handling and storage. Rawmaterial quality and suitability for chips, French fries, dehydrated granules and boiled/canned potatoes; processing for chips

6.17. POTATO PROCESSING

Solanum tuberosum L., the potato, is a After rice and wheat, potatoes are the third-most significant food crop in the world, and they are crucial for human consumption. Since potatoes include carbohydrates (16%), proteins (2%), minerals (1%), dietary fibres (0.6%), and are a good source of vitamin C and antioxidants, they are regarded as a non-fattening, nutrient-dense, and healthful food. Potato tubers are used for a variety of things, including food, animal feed, industrial (for alcohol and starch), and table use. You can prepare potatoes in a variety of ways to eat them, such as baking, boiling, roasting, frying, steaming, and microwaving. Potatoes can be served in every course of a meal, including salads, appetisers, soups, and the main course, where they can either function as the main dish or as an accompanying side dish. Fresh potatoes are increasingly being replaced by processed potato goods including mashed and tinned potatoes, fries, and chips throughout the world.

About 68% of potatoes are used for table use in India, followed by 7.5% for processing, 8.5% for seed, and 16% of output that is handled improperly before and after harvest is wasted. In the plains of North India, where about 90% of the potatoes are grown throughout the winter, harvesting is followed by a scorching summer, which makes it challenging to store potatoes under normal circumstances. Overproduction is frequently caused by a small increase in land area, the adoption of high yielding varieties, and favourable meteorological conditions. A portion of the potato farmland must be set aside for production in the value-added or processing sector in order to stabilise prices and prevent the recurring surplus crises.

Additional factors that have caused potatoes to move from kitchen and dining tables to pouches and packs that are popular with everyone include increased urbanisation, an increase in per-capita income, an increase in the number of working women, changing food preferences, and a preference for ready-to-eat snacks. Growing processing types of potatoes is very lucrative for farmers since processed goods are expanding market opportunities in both the domestic and international markets. In addition, it is simple to prepare dehydrated chips, cubes, and other items at the small-scale industry level, which can help rural youth and village women find work. The value addition of potatoes helps increase crop diversity, agricultural incomes, and nutrition while also generating value exports and new jobs.

(a). Potatoes for Processing

The potato processing industry is highly industrialised, highly developed technologically, and market-driven. However, the quality of processed goods and the industry's financial viability are reliant on the year-round availability of potato raw materials. For the potato processing business, this means that the availability of suitable cultivars, potato production, quality in all of its manifestations during the growing season, and strong post-harvest (storage) performance are of the utmost importance. Through agreements and direct communication with farmers, processors manage their own supply (chain) of potatoes. They provide farmers with seed potatoes as well as services and advise on best growing and storage practises. The raw potato material obtained from potato growers translates into the quality criteria of the processed products as demanded by the market.

These potatoes have an acceptable length or size for French fries, a good form, a high dry matter content, and a low reducing sugar level. Potato chips, French fries, potato flakes/powder, and other processed items like dried chips, Alu Bhujia, Samosa, and Tikkis are the four primary segments of the potato processing business in India. But potato chips are still the most widely used and favoured processed good.

6.11.1. Quality Requirements of Potatoes

The ability to match market requirements, the consumer's preferred cuisine, or aesthetic appeal are all indicators of quality. The quality of product is determined by factors such tuber size, shape, appearance, lack of diseases or abnormalities, flavour, and texture for a variety of uses. Potatoes can be used for a variety of purposes depending on their dry matter content and texture. High solids are correlated with a mealy texture, while low solids are correlated with a waxy texture. For fried and dehydrated items, potatoes with a dry matter content of more than 20% and a mealy texture are desired, whereas little potatoes with a dry matter content of 18 to 20% and a waxy texture are chosen for creating salads and canning. For various uses, particular traits in potato types are necessary.

6.11.2. Morphological Attributes

Size, shape, and eye depth of the tubers: 45 to 85 mm tubers are thought to be optimum for producing chips that are the desired size. To produce chips that are consistently round, tubers with a round shape are ideal, though ovoid-shaped tubers can still be used. Oblong or long oval tubers (75-110 mm) are preferred for generating high-quality French fries, and round to oval shapes (30-85 mm) are preferred for flakes. Small tubers with a round to oval form are good for canning. Tubers with shallow or swift eyes are preferable in processing variety to ensure less peeling losses.

6.11.3. Tuber defects:

The quality of completed products is impacted by a potato fault, whether internal or external. Inadequate shape or size, knobbiness, cracking, deterioration, greening, etc. are examples of external flaws. Internal faults, such as a hollow heart, a brown centre, internal brown spots (IBS), etc., are flaws that appear inside the tubers. These could be brought on by pathological or physiological factors. In addition to lowering product quality, more faults in the raw material increase the labour needed during tuber sorting and ultimately raise operating costs.

6.17.4. Biochemical Attributes

Dry matter and specific gravity of tubers: A potato typically comprises 80% water. The relationship between tuber dry matter and tuber specific gravity is positive. The most crucial factor affecting the quality and production of fried and dried items is the dry matter content of the tubers. The best potatoes to use when making fried and dehydrated foods are those with a high dry matter content. For canning, a dry matter level of 18–20% is regarded as appropriate; however, for chips, French fries, and other dehydrated goods, the dry matter content should be greater than 20% or > 1.080 specific gravity. Higher dry matter or solids content leads to higher processing product recovery, less oil absorption, less energy use, crispier product texture, and eventually a lower risk of obesity.

6.17.5. Reducing sugars:

The colour of fried foods like chips and French fries is greatly influenced by the reducing sugars (glucose and fructose) found in tubers. High-temperature frying produces "Maillard reactions" when sugars interact with nitrogenous molecule amino acid groups to produce dark-colored chemicals. A darkly coloured, bitter potato product is the result of this. 'Maillard reactions' are also linked to the production of acrylamide, which is regarded as a potentially hazardous substance, in addition to the undesirable colour and flavour of fried items. Fry colour appears to be primarily influenced by the glucose content of the tubers, but fructose concentration can also have a significant impact on fry colour.

The levels of sucrose (nonreducing sugar) do not significantly correspond with the hexose sugar concentrations or the colour of the fries. For the purpose of making chips, sugar level must be reduced to under 100 mg/100g of fresh tuber weight. It is allowed to reduce the sugar content in goods like French fries and dried foods by up to 150 mg per 100 grammes of fresh tuber weight.

6.17.6. Phenols:

Tubers exhibit enzymatic discoloration as well as after-cooking discoloration in addition to the frying-related discoloration. Peeling, cutting, or other damage to the potatoes might cause enzymatic discolouration. Some of the components in the tubers, such as polyphenols, interact with oxygen (air) to generate o-quinones, which eventually result in a brownish hue. If potatoes are submerged in water rather than exposed to air, this form of discolouration can be avoided.

6.17.7. Glyco-alkaloids:

The inherent glycoalkaloid content of cultivars varies; at lower concentrations, it has been hypothesised that they might improve potato flavour, but at higher concentrations (above 15 mg/100g fresh weight), they add bitterness, and levels above 20 mg/100g fresh weight are thought to be unsuitable for human consumption and result in symptoms that are usually related to food poisoning.

6.17.8. Other attributes:

Potatoes with unique qualities are gaining popularity, such as those with colourful skin or meat that contains more anthocyanins, better flavour or texture, higher nutritional value (strong in zinc and iron, anthocyanin/carotene/antioxidant content, or low glycemic index). A food's ability to quickly and significantly increase our blood glucose (blood sugar) level is measured using a scale known as the glycemic index (GI). A low GI food will normally cause a little rise in blood sugar, whereas a high GI item may cause blood sugar levels to rise above the recommended range. Potato has a wide range of glycemic index values. It is necessary to take advantage of the variation in glycemic index values among different potato genotypes and variations in order to promote genotypes with low GI. These speciality potatoes command high prices in the market and may one day be potential value-added products.

6.17.9. Colour of processed products:

The colour of the fried product is determined by frying chips or fries in hot oil at 180° C until the bubbling is gone (1–10 scale: 1- very light and desirable colour, and 10- dark and unpleasant colour). For chips, a colour up to 3 is preferred, and for French fries, a colour up to 4.

6.18. Development of Potato Varieties for Processing Industry in India

In 1990, the ICAR-Central Potato Research Institute began a breeding programme to create indigenous processing varieties, keeping in mind the demand for high-quality raw materials. The first two processing varieties, Kufri Chipsona-1 and Kufri Chipsona-2, were introduced in India in 1998. The availability of these cultivars and the standardisation of storage technologies for potatoes at elevated temperatures (10–12 oC) for processing led to the country's potato processing sector developing quickly. Kufri Chipsona-3, which has a larger percentage of defect-free processing grade tubers, was created in the year 2006. After the creation of Kufri Chipsona-3, efforts were focused on creating a processing variety that would be ideal for hills and could supply the raw materials needed by the processing industry after July/August.

Due to the weak and uneven quality of the tubers and the collapse of late blight resistance, the output of the common variety of hills, Kufri Jyoti, did not reach the processing standards. Due to this, a Kufri Himsona variety suited for the hills was created in 2008, ensuring the processing industry's access to raw materials throughout the off-season.

Another obstacle for the processing business was the lack of specialised processing options for French fries. French fries were either prepared from the locally grown Kufri Chiposna-1 variety, which produced limited yields of French fry grade tubers, or imported frozen to satisfy demand.

The institute created and produced Kufri Frysona for the north Indian plains in 2009 with the long-felt need for French fry diversity in mind. The aim was on the development of early bulking, late blight-resistant processing varieties needed for Karnataka, West Bengal, and Madhya Pradesh because all of the country's native processing varieties were of medium to long duration (100-110 Days).

In 2010 the region-specific processing early variety Kufri Chipsona-4 for the plateau regions of Karnataka, West Bengal, and Madhya Pradesh was created and released. Due to the Indian French fry variety Kufri Frysona's late maturity, there was a need to create a French fry variety with a medium maturity group that produced the best yield of processable grade. 2018 saw the recommendation of the advanced potato hybrid MP/4-578.

6.19. PACKAGING AND STORAGE OF MINIMAL PROCESSED FRUITS AND VEGETABLES

Modified-Atmosphere Packaging and Edible Coatings Packaging and storage is the last operation in the production of minimally processed fruits and vegetables. The most appropriate packaging method for precut raw fruit and vegetable is modified-atmosphere packaging (MAP). The basic principle in MAP is to create a modified atmosphere either passively or by using permeable packaging materials and by using a specified gas mixture with permeable packaging. The main purpose is to create an optimal gas balance inside the package, where the respiration activity of a product is as low as possible, but the levels of oxygen and carbon dioxide are not detrimental to the product. In general, the aim is to have a gas composition of 2-5% CO_2, 2- 5% O_2 and the rest nitrogen. However, Optimal O_2-CO_2 atmosphere cannot be maintained by use of most of the films, especially when the produce has a very high level of respiration. One solution to this problem is to make microholes of a defined size and defined number in the matter to avoid anaerobiosis. MAP is being used commercially for minimally processed lettuce, carrots and cabbage although current design is not sufficient to prevent the onset of fermentation under normal marketing conditions. In these cases, fermentation alters the flavour and quality of the product. This approach will not work for products such as broccoli that produce offensive off-flavour.

Packaging films such as combinations of ethylene vinyl acetate with oriented polypropylene and low density polyethylene have proved useful as these combinations have significantly high gas permeability. The shelf-life of shredded cabbage and grated carrots packed in these composites is 7-8 days at 5o C. This is 2 days higher than oriented polypropylene which is generally used in the vegetable industry.

Temperature management after packaging is very essential, for minimizing the damaging effects of mechanical injury. Low temperature storage reduces metabolic reactions. It has a tremendous effect on respiration rates, and affects permeability of gases through packaging films and also slows down microbial growth. To ensure high quality products it is recommended that fresh cut products be kept at temperatures just above freezing. Usually 4-6o C temperature is recommended for storage of fresh precut produce.

6.20. POTATO CHIPS PROCESSING:

In potato processing, the on-chip colour and flavour in particular are taken into account while determining the type of potato chips. While heavy brown-colored shaded chips are undesirable, the bright gold-yellow tone is preferred. There are many different kinds of potato chips, such as low-fat chips, etc., and the preferred size for producing chips is 40 to 60 mm.

A potato chip is a thin potato slice that has either been pan-fried or cooked till it is crunchy. Usually, they are served as a snack, side dish, or appetiser. The basic chips are cooked and salted; further varieties are made with various flavourings and ingredients, such as spices, flavours, cheeses, other typical flavours, fake flavours, and additional ingredients.

Potato chips structure an enormous part of the snack food and comfort food market in Western nations and Potato Processing plays an important role in that. The worldwide potato chip market produced an income of US$48.49 billion in 2015. This represented 47.5% of the all-out exquisite bites market in that year ($98.1 billion).

6.14.1. POTATO STARCH

The creation of Native Potato Starch, Modified Potato Starch, Soups, Gravy, and Puddings are all examples of uses for potato starch, which is a byproduct of the processing of potatoes. Starch is a softening substance that is used in cookies, cakes, bread, and biscuits. Due to its strong restraining force, it is useful in the paper industry for coating smooth white paper. The organisation of dextrins, adhesives, glues, medicines, binders, etc. are examples of other uses.

6.14.2. POTATO FLAKES

Potatoes can be preserved by drying them out or lightly frying them to reduce moisture content and the likelihood of microbial growth. Potato flake seeds are frequently used in the manufacture of ingredients for dishes like Aaloo Parantha, Aloo Tikki, Samosa, Aloo Bhaji, and Potato Flakes, among others.

6.14.3.DEHYDRATED GRANULES AND BOILED/CANNED POTATOES

Dehydrated potato goods, such as potato flakes and granules, are processed foods prepared from whole, fresh potatoes that have been cleaned, peeled, sliced, cooked in advance, cooled, and then mashed before being either drum dried into flakes or air dried into granules.

6.14.4.FOOD USES: FRESH, FROZEN, DEHYDRATED

A dizzying array of dishes, including mashed potatoes, potato pancakes, potato dumplings, twice-baked potatoes, potato soup, potato salad, and numerous other snacks, can be made using fresh potatoes by baking, boiling, or frying them.

However, the world's consumption of potatoes as food is moving away from raw potatoes and towards processed foods with added benefits. Frozen potatoes, or "chips" as they are known in the UK, are one of the key products in this category and make up the majority of the french fries and fast food franchises served worldwide. More than 7 million tonnes of factory-made french fries are consumed globally each year, according to estimates. Another manufactured meal that has long reigned supreme in many industrialised nations is the potato crisp (known as "chips" in the US).

Dehydrated potato flakes are present in commercial mashed potatoes. The food sector uses potato flour, another dehydrated product, to bind meat mixes and thicken gravies and soups.

Potato starch, a fine, flavourless powder with "excellent mouth-feel," has a higher viscosity than wheat and maize starches and produces tastier results. It serves as a binding factor in cake batter, dough, biscuits, ice cream, and sauces and stews.

Crushed potatoes are heated in eastern Europe and Scandinavia to turn their starch into fermentable sugars that are utilised in the production of alcoholic drinks like vodka and akvavit.

6.14.5. NON-FOOD USES: GLUE, ANIMAL FEED, AND FUEL-GRADE ETHANOL

The pharmaceutical, textile, wood, and paper industries all utilise potato starch extensively as an adhesive, binder, texturing agent, and filler. Oil drilling companies also use it to clean boreholes. Polystyrene and other plastics can be replaced with potato starch, which is 100 percent biodegradable, in products like disposable plates, dishes, and knives.

Starch-rich potato peel and other "zero value" byproducts from potato processing can be liquefied and fermented to create ethanol that is suitable for use in fuel. According to a research conducted in the Canadian province of New Brunswick, which also produces potatoes, 44,000 tonnes of processing waste may provide 4-5 million litres of ethanol.

Up to half of the potato crop is utilised as farm animal feed in the Russian Federation and other east European nations.

Pigs quickly gain weight on a daily diet of 6 kg of boiling potatoes, whereas cattle can be given up to 20 kg of rawpotatoes. The tubers cook in the heat of the fermentation when they are chopped up and fed to silage.

6.21. FRUIT-BASED CONCENTRATES, SQUASHES, JAMS. JELLIES, MARMALADES

6.19.1. Squashes

Squash should contain at least 25% fruit juice or pulp and 40 to 50% total soluble solids commercially. About 1% citric acid and 350 ppm Sulphur dioxide or 600 ppm sodium benzoate are added as preservatives. Squash is a beverage comes under RTS category. Any type of fruit can be used for preparation of squashes.

6.19.2. FRUIT JAM

Jam is a product that is prepared by boiling fruit pulp with enough sugar and has a consistency that is relatively thick, solid enough to hold the fruit tissues in place, and edible. Jams contain 0.5-0.6% acid, and the percentage of invert sugar shouldn't exceed 40%. Section No. contains the FPO jam specs.

A. Preparation of Jam

Jam can be made with just one type of fruit or with two or more. Almost any type of fruit can be used to make it. Jams are made with ingredients like apple, papaya, carrot, strawberry, mango, grapes, pineapple, etc. Fruit may be combined in many various ways to benefit the consumer, with pineapple being one of the greatest options due to its strong flavour and acidity.

B. Preparation of fruit pulp:

Sound fruit is sorted, prepped, and either brush-washed or cleaned under running water as preferred. The method of preparation differs depending on the fruit's characteristics. Mangoes, for instance, are peeled, steamed, and pulped; apples, on the other hand, are peeled, cored, sliced, heated with water, and pulped; plums, on the other hand, are scalded and pulped; peaches, on the other hand, are peeled and pulped; and berries, on the other hand, are heated with water and pulped or cooked as such.

C. Addition of sugar:

You can use up to 25% corn syrup as a sweetener while making jams and jellies. When making jams, high-quality cane sugar is typically utilised. Fruit type, variety, maturity stage, and acidity all affect how much sugar is present in the fruit. In general, a 1:1 fruit pulp to sugar ratio is used. Berry, grape, plum, apricot, pineapple, and other tart fruits are typical candidates for this ratio.

D. Addition of acid:

Various fruits naturally contain tartaric, malic, or citric acids. When producing jam, these acids are also added to the fruits to balance the acidity of those that lack natural acids. Since a sufficient ratio of sugar, pectin, and acid is needed to give the jam a satisfactory set, acid addition becomes necessary. Fruit juice and pectin should be combined at a pH of 3.1. Depending on the type of jam, the finished jam can have an acidity of between 0.5 and 0.7%. It is frequently advised to add acid towards the end of cooking, which causes more sugar to invert. When acid is applied at the start, the set will be bad.

E. Processing/boiling:

Fruit pulp is boiled to 69% Total Soluble Solids (TSS) with the necessary amounts of pectin and sugar. At thispoint, flavourings, the required quantity of citric acid, and approved food colours are added. In addition to removing extra water, the boiling procedure partially inverts the sugar and develops its flavour and texture. Each and every microbe inside the jam is eliminated during the boiling process. When this is hotly poured into clean containers that are then sealed and turned upside down, the hot jam contacts the lid surface and stops microorganisms from spoiling the jam during storage.

6.19.2.1. Judging of End Point

Jam concentration is finished at the ideal stage to prevent overcooking, which causes financial losses owing to decreased yield. However, undercooking will cause jam to ferment during storage, causing it to deteriorate. The following techniques can be used to pinpoint where jam finishes or ends. In situations where there are no other facilities available, housewives frequently utilise the drop test method since it is the simplest way to assess when jam has finished setting. This method involves taking a small amount of jam in a tea spoon from the hot pan and letting it cool completely before adding a drop to a glass of water. The point at which the drop settles down without disintegrating indicates completion. Figure 10. Determination of end point of jam/jelly (a) (b)

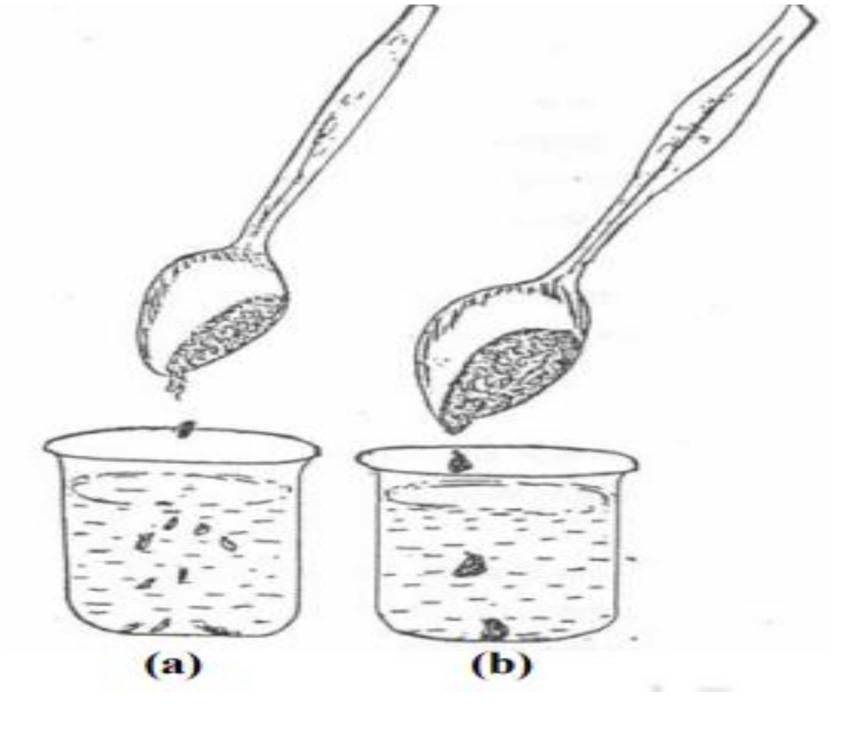


Figure 10.1: drop test. a) Unfinished; b) End point

6.19.2.2. **By sheet test**

In order to do this test, a tiny amount of jam is scooped up with a big spoon or wooden ladle, allowed to cool slightly, and then allowed to drip out while maintaining the spoon or ladle in a horizontally inclined posture. Further concentration is required if the jam starts to drop like syrup. The ending stage is reached if it takes the form of a flake or a sheet.

6.19.2.3. **Refractometer method**:

The majority of small and large-scale fruit processing enterprises employ this technique while creating jam. As soon as the refractometer registers 69 o Brix, the cooking is terminated.

6.19.2.4. **Boiling point method**:

Boiling point technique, shows that jam containing 69% TSS boils at 106 oC at sea level. The easiest and most effective approach for figuring out when jam will finish is this one.

6.19.2.5. **By weighing method:**

The weighing procedure requires more work and time. Here, the boiling pan is weighed both before and after the extract and sugar have been added to it. When the net weight of the jam is 1.5 times the amount of sugar added, the goal is reached.

6.19.2.6. **Packaging**

The product is packed in cans or glass jars, and cooled, followed by labelling and packaging. Containers including can or jar gets sterilized when hot jam (not less than 85o C) is poured in them. Boiling the containers in hot water can also effect sterilization.

6.19.3. Special Care/ Problems in Jam Production

6.19.3.1. **Crystallization:**

6.19.3.2. Invert sugar should make up 30–40% of the finished product. Cane sugar may crystallise during storage if the percentage is less than 30, and if it is greater than 50, the jam will turn into a mass resembling honey due to a high inversion of sugar into glucose. Cane sugar can be used with glucose or corn syrup to prevent crystallisation.

6.19.3.3. **Sticky or gummy jam:**

Jams have a propensity to gel or stick to the touch because to the high percentage of total soluble solids. The solution to this issue is the inclusion of pectin, citric acid, or both.

6.19.3.4. **Premature setting:**

This is caused by the jam's high pectin level and low total soluble solids, and it can be avoided by boosting the sugar amount. In the event that this is not possible, a tiny amount of sodium bicarbonate is given to lessen the acidity and avoid pre-coagulation.

6.19.3.5. **Surface graining and shrinkage:**

This results from the moisture in the jam evaporating while it is being stored. It can be decreased by storing somewhere cool.

6.19.3.6. **Microbial spoilage:**

Jam can be stored at a relative humidity (RH) level of less than 90%, preferably 80%, to prevent mould growth. In the form of KMS, 40 ppm sulphur dioxide is also advised to be added. Sulphur dioxide shouldn't be added to jam when using cans since it will cause the can's interior surface to turn black.

6.20. FRUIT JELLY

The process of making jelly involves boiling a clear, strained solution of pectin that contains fruit extract devoid of pulp, together with sugar and acid. A ideal jelly should be translucent, well-set but not overly rigid, and retain the flavour of the fruit it was made from. When taken from the moulds, it should maintain its shape and have a pleasing colouring. It must be both tough enough to keep a sharp edge and delicate enough to tremble when squeezed. It shouldn't have crystallised sugar, be gooey, sticky, or syrupy. The product shouldn't be tough or rubbery, and it shouldn't be uninteresting with little to no syneresis.

6.20.1. Preparation of Jelly

Fruit juices and sugar are boiled to create jellies, which may or may not also contain pectin and food acids. Jellies are often made from juices from just one type of fruit, which are then heated to extract as much soluble pectin as possible. a variety of fruits Jelly is typically made with guava, sour apple, plum, papaya, some types of banana, and gooseberries. Since these fruits have a low pectin concentration, they can also be utilised, but only after being supplemented with pectin powder. Fruits can be categorised into four classes based on how much pectin they contain. Because pectin is a crucial ingredient that determines the jelly's texture, this classification is very helpful when making jelly.

The classification is as follows.

• Rich in pectin and acid: sour apple, grape, lemon, sour oranges, jamun, sour plum.

• Rich in pectin but low in acid: apple, unripe banana, pear, ripe guava, etc.

• Low in pectin but rich in acid: sour apricot, sweet cherry, sour peach, pineapple and strawberry.

Low in pectin and acid: ripe apricot, peach, pomegranate, strawberry and any other overripe fruit.

6.20.2. Extraction of pectin/boiling:

The fruits are carefully cleansed after selection, much like when making jam, as was previously stated. To produce the highest production of juice and pectin, the majority of fruits are cooked before the juice is extracted. Fruit tissues become softer and protopectin is converted to pectin during boiling. Very juicy fruits are mashed and boiled to boiling for only five minutes without the need for additional water. Cut or crushed firm fruits are cooked in water for five minutes. The variety and texture of the fruit will determine the length of the boiling process. The fruit must be given enough water to produce a high output of pectin; for example, apples require half to an equivalent volume of water, whereas citrus fruits require2-3 volumes of water for each volume of sliced fruits.

6.20.3. Straining and clarification:

By straining the cooked fruit mass through bags made of linen, flannel, or cheese cloth that have been folded multiple times, pectin extract can be obtained. Fruit extract is produced to pass through filter presses for clarity during large-scale processing.

6.20.4. Analysis of extract:

By using standard scientific techniques, clarified extract is examined for pH, acidity, soluble solids, and pectin content. The simplest method used to determine pectin content is precipitating the pectin with alcohol. By combining a small sample of juice with an equivalent volume of 96% alcohol in a tube, you may quickly assess the pectin level of juice. The mixture is then dumped onto a plate from the tube. A sufficient pectin concentration for jellification is indicated by the presence of a compact gelatinous precipitate (Figure 10.4). Many little granular lumps of insufficient pectin will remain after processing..

6.20.5. Addition of sugar and pectin:

Calculating the appropriate amount of sugar to add is done using the fruit extract's pectin test results. Sugar is added in an amount equivalent to the amount of pectin-rich extract. For every kg of the extract with moderate pectin, 650–750 g of sugar should be added. Without the need to add pectin, jellification will take place for pectin-rich fluids. If there is less pectin in the juice, 1-2% powder pectin will be added.

6.20.6. Addition of acid:

As hydrogen ion concentration rises, jelly strength rises as well, reaching its peak at an ideal pH of 3.2 at 65% sugar concentration. The amount of pectin and acid in the original fruit extract affect how strong the jelly will set.

6.20.7. **Processing/boiling:**

6.20.8. To eliminate around half of the water that needs to be evaporated, the juice is heated up to a boil. The calculated sugar amount is then gradually added. Once a TSS (refractometric extract) of 65% is attained, the remaining water is evaporated. It's important to eliminate any foam or scum that forms during boiling. Product acidity needs to be increased to a pH level over 3, or around 1% (malic acid). Any acid addition is always carried out after boiling. Jellies are boiled in tiny batches (25–75 kg) to prevent pectin degradation from occurring from an unduly extended boiling period.

6.20.9. Judging of End Point

It is not advisable to boil jelly for an extended period of time because doing so increases sugar inversion and destroys pectin. Sheet test, drop test, refractometry, thermometer, and boiling mass weighing can all be used to determine the end point.

Methods including sheet testing, drop testing, and boiling mass weighing can be carried out similarly to how jam is made.

6.20.10. Refractometer method:

In the industries that process fruit, this is the method that is most frequently employed to make jelly. 65^0 Brix on the refractometer signals the end of cooking.

6.20.11. Packaging

When jelly is finished, the froth is removed by skimming. It is briefly chilled before being poured into hot, dry glass jars. Cooling is optional and is done in double-walled bathtubs with water circulation up to 85 degrees Celsius. In order to allow chilling and product jellification, filling must be done in containers (such as glass jars) that must be kept still for around 24 hours after the filling process.

6.20.12. Important Considerations in Jelly Making

The four components that make up jelly are pectin, acid, sugar (65%), and water.

The quality of the jelly is greatly influenced by the pectin test and the assessment of the point at which jelly is formed.

(a). Pectin:

The most crucial component of jelly is pectin. Up until a certain degree, the concentration of pectin in the gel enhances its stiffness; but, after that point, adding additional pectin has minimal impact. Insufficient pectin results in mushy syrup rather than gel. By serving as a protective colloid, pectin helps prevent the crystallisation of sugar, however it is ineffective when the sugar concentration is 70% or higher. The method of extraction, the ripeness of the fruit, the volume of water added to extract the juice, and the kind of fruit all affect how much pectin is extracted. Typically, the extract only needs between 0.5 and 1.0% of pectin to yield acceptable jelly.

A solid and tough jelly forms when the pectin content is higher; if it is lower, the jelly may not set.

(b). Acid:

Juice & Drinks The amount of acid and pectin in the fruit determines how jelly-like the extract will be. Comparing tartaric acid to citric and malic acids, a better outcome is obtained. The overall acid content of the finished jelly should be at least 0.5% but not more than 1%. A higher acid concentration could result in jelly syneresis.

©. Sugar:

This jelly component, which gives the jelly its sweetness and body, is crucial. A hard jelly results from the jelly retaining less water when the sugar concentration is high. Acidic sugar is hydrolyzed into dextrose and fructose when it is cooked. The jelly contains a mixture of sucrose, glucose, and fructose as a result of this partial inversion of the sucrose. The jelly may keep more sugar in solution without crystallising since this mixture is more soluble in water than sucrose alone.

6.21. MARMALADE

Slices of the fruit or its peel are suspended in this fruit jelly. When shredded peel is used as the suspending material in products manufactured from citrus fruits like oranges and lemons, the phrase is typically employed. Marmalade is made by keeping the pectin and acid concentrations greater than those of jelly. Bitterness is seen as a desirable product quality. Marmalades are divided into two categories: jam and jelly..

6.17.1 Jelly Marmalade

A 2:1 ratio of sweet orange, mandarin orange, and sour orange can be used to make high-quality jelly marmalade. Peel from a sweet orange (from Malta) is used to make the recipe.

6.17.2. Preparation of Jelly Marmalade

Sorted, cleaned, and prepared fruit that has reached maturity. The method of preparation differs depending on the fruit's characteristics. After that, the fruits are sliced and cooked to create the extract.

6.17.3. **Extract preparation:**

Pectin is extracted, the extract is filtered or strained, and it is then analysed in the same manner that jelly is prepared.

6.17.4. Preparation of peel shreds:

Peeling off the yellow section of citrus fruits' outer skin with care. Slices of the stripped-off peel that are 2-2.5 cm long and 1-1.2 mm thick are made from it. The shreds can be softened by boiling them in water containing 0.1% ammonia solution or 0.25% sodium bicarbonate. The shreds may be held in heavy syrup for a while before being added to the jelly to improve their bulk density and prevent floating when combined with the jelly.

6.17.5. Boiling:

Before sugar is added, the fruit extract is heated. The contaminants, which often take the appearance of scum, are eliminated during boiling. Peel shreds are made and added to the mixture at a rate of 5-7% of the original extract once it reaches a temperature of 103° C. Up until the point of no return, boiling is continued. The finished result is evaluated similarly to how jelly was evaluated. Marmalade has 65% TSS at 105°C, much like jelly. To obtain a bright and sparkling marmalade, the boiling process should not last longer than 20 minutes following the addition of sugar..

6.17.6. Cooling:

The marmalade is chilled to allow the surrounding syrup's shreds to absorb sugar. The shreds could rise to the surface if the marmalade is added hot as opposed to staying suspended. The product is occasionally gently swirled while cooling to ensure that the shreds are distributed evenly. The viscosity of the syrup increases as the marmalade reaches a temperature of about 85° C, and a thin coating starts to form on the surface, preventing shreds from rising to the surface.

6.17.7. Flavouring:

To replace the flavour that is lost during boiling, flavouring or orange oil is added to the product near the conclusion of the boiling process. Usually, before packing marmalade into containers, a few drops of orange oil are incorporated into the jam.

6.17.8. Packaging and Storage:

Marmalade is poured into jars and cans at a temperature of about 850 C, just like jams and jellies. Marmalade must be stored in dry areas with a relative humidity of no more than 75%, which are also well-ventilated, medium cool (10 to 20 °C), clean, and out of the direct sun and heat. These precautions are required since marmalade is a hydroscopic product and water absorption leads to the creation of mold-friendly conditions.

6.17.9. Jam Marmalade

The process for making jam marmalade is essentially the same as that for making jelly marmalade, with the exception that the pectin extract is not clarified. After the albedo section of the orange peel has been removed, the peel is cut into 0.3 cm-thick pieces and processed as directed for jelly marmalade. After removing the peel, orange, lemon, or grapefruit slices are combined with a small amount of water and cooked to soften. To remove the seeds and obtain thick pulp, the cooked mixture is run through a coarse pulper. The pulp is combined with an equal amount of sugar and boiled until it reaches a 65o Brix or jam-like consistency. When the jam is just beginning to cool, the treated shreds are combined with it.

Before putting the marmalade into containers, some orange oil is also combined with it. The same method used for jelly and jelly marmalade packing is used for filling and packaging.

6.17.10. Problems in Marmalade Making

By adding 0.09g of potassium metabisulphite (KMS) per kilogramme of marmalade and avoiding the use of tin cans, browning during storage can be prevented. KMS that has been dissolved in some water is added while the marmalade cools. KMS also eliminates the chance of mold-related degradation.

6.22. FUTURE THRUST

The amount of potato tubers that are transformed into different products worldwide is roughly 15.5%, making them an important choice for food security. In Europe and the USA, the value-added or processing industries for potatoes are well-established, and 30–69% of the overall production is transformed into various goods. On the other hand, India is expanding and is on its way to experiencing a "crispy revolution" as a result of the sector's explosive expansion and quick advancement. The amount of potato processing activity in both the organised and unorganised sectors has expanded from 1% in the late 1990s to about 7.5% in the current situation due to the availability of acceptable raw materials and the adoption of improved storage techniques.Farmers would profit from a decrease in postharvest losses, and the nation's food and nutritional security would improve.

6.23. CONCLUSION

You must now realise that adding sugar and then concentrating the mixture through evaporation to a degree where microbial deterioration is stopped is the fundamental idea behind the creation of sugar-based products. We have also seen the value of sugar and other sweeteners as well as how they are used in processed foods like jam, jelly, and other items. This section goes into detail about how to make jam, jelly, marmalade, and other sugar-based products. They also detail the extra care that was used throughout their preparation. There is also a small notice about packaging and quality standards.

KEY WORDS

Artificial sweeteners : They are synthetic, calorie free, high intensity sugar substitutes, sometimes used in place of other sugars in food manufacturing and cooking.

Glazing : Coating candied fruit with a thin transparent layer of sugar, which imparts them a glossy appearance, is known as glazing.

Crystallized fruit : These are candied fruits covered or coated with crystals of sugar.

Jam : Jam is a product with reasonably thick consistency, firm enough to hold the fruit tissues in position, and is made by boiling fruit pulp with sufficient sugar.

Jelly : Jelly is a semi solid product prepared by boiling a clear, strained solution of pectin containing fruit extract, free from pulp, after addition of sugar and acid.

Humectancy : Ability to retain water.

Inversion of sugar : Inversion is a chemical process in which sucrose breaks down to its constituent sugars: glucose and fructose.

Marmalade : Marmalade is a fruit jelly in which slices of the fruit or its peel are suspended.

Exercise

1. write down the composition of fruits and vegetables.
………
2. what do you mena by climacteric and unclimactic fruits.
……
3. Define ethylene production and ripening process.
……
4. what do you mean by flavour change.
……
5. Textural changes in fruits.
………
6. Define processing of potato
…………………………..
7. Define chips making process.
……………………

SUGGESTED READINGS

CPRI. 2013. Vision-2050. Central Potato Research Institute, Shimla, India.

Dale, MFB and GR Mackay. 1994. Inheritance of table and processing quality. In: Potato Genetics (Bradshaw, JE. and GR Mackay, Eds.) pp. 285-315. CAB International, Wallingford.

Gaur PC, SK Pandey, SV Singh and Dinesh Kumar. 1999. Indian Potato Varieties for Processing. Tech. Bull. 50, Central Potato Research Institute, Shimla, India. 25 p.

Gupta VK, SK Luthra, and BP Singh. 2014. Potato processing varieties: Present status and future thrusts. National seminar on post-harvest management and processing of potato for increasing food security in India. 22 Sep, 2014, UAS campus, Dharwad, Karnataka, India

Gupta VK, SK Luthra and BP Singh. 2014. Breeding potatoes for value addition: A comprehensive approach for sustainable potato production. National seminar on emerging problems of potato, November 1-2, 2014, Central potato Research Institute, Shimla, HP,India : p159

Larry K H, DC Koller and RE Thrnton. 1979. Physiological disorders of potato tubers In Paul Li (ed.) Potato Physiology.

Luthra, SK, PC Pande and BP Singh. 2004. Perspective planning for developing potatoes for export. In Processing & Export Potentials of Indian Potatoes (Eds. SM Paul Khurana, BP Singh, SK Luthra, NR Kumar, Devendra Kumar and Dinesh kumar).

International Potato Conference & Fest-'04, CPRI Campus, Modipurarm, Meerut. IPA, Shimla. pp 18-27

Unit VII: Milk and Milk Products

Structure:

OBJECTIVES

After reading this unit, we should be able to:

- State the purpose of some of the basic milk processing operations.
- Differentiate between filtration and clarification of milk.
- Define what 'separation of milk' means and what factors affect the same.
- Enumerate other centrifugal processes viz. bactofugation and clarification.
- Specify 'standardization' means and how to carry our the same.

7.0 . MILK PROCESSING INTRODUCTION

As we previously learned, it is crucial to keep the milk refrigerated as soon as possible after milking until it is delivered to the processing facility. At the dairy facility, it might

(i) processed for distribution in fluid form as market milk, or

(ii). converted into various products.

In either scenario, it must undergo a few fundamental procedures before being processed further. At a dairy facility, milk must go through filtration or clarification, separation, and standardisation processes. These are intended to purify and alter the composition of the milk. The goals of these therapies and the methods used to carry them out will be covered in this unit. In actuality, milk is centrifuged (in specialised centrifugal machines) to achieve separation and clarification. This course will also briefly cover several more centrifugation-based milk processing techniques like "clarifixation" and "bactofugation."

7.1. FILTRATION AND CLARIFICATION OF MILK

7.1.1. Purpose The amount of visible and invisible contaminants in raw milk that is generated on a farm and transferred to a dairy factory or collection centre varies. Straw and hair fragments, dust particles, leukocytes (white blood cells or somatic cells), insects, and other foreign objects are examples of this foreign matter. Such extraneous insoluble debris, which can lead to deposits in milk handling machinery like coolers, etc., if not properly cleaned, can also lead to an ugly look. Larger fragments of this debris, like straw, hair, and insects, are typically removed by'straining' the milk by running it through a fine metal-gauge strainer or metallic sieve on the farm, at the collecting site, or at the processing facility. Additionally, there are tubular sieves utilised in the milk inlet pipe to the processing unit (such as the pasteurizer). A centrifuged clarifier or a specific filter must be used for clarifying when removing finer foreign materials. The solution to the sedimentation issue in fluid milk and liquid milk products in general, and homogenised milk in particular, is to utilise these measures for product aesthetic improvement.

7.1.2. **Filtration** Making the milk flow through a filter-cloth or filter-pad is referred to as filtering (or clarifying using a filter-bag). Most of the foreign matter can be kept on the filtering media due to its pore size (25-100 mm). A perforated stainless steel (SS) support, a nylon filter bag or pad, a milk distributor, and inlet and output connections make up the milk filter, which is housed in an SS enclosure with a tight-fitting cover. Typically, milk flows from top to bottom. When there are two filters, three-way valves in the inlet and outlet lines allow you to switch between them when the first filter needs cleaning. In modern continuous pasteurising systems (high-temperature short-time, or HTST pasteurizers), filters may occasionally be provided in the shape of cylindrical bags or "stockings" fitted over perforated SS tubes. Either warm milk (40–45o C) or cold milk (approximately 10o C) can be used for filtering. Warm milk filtering is widely utilised since it is quicker and has less viscosity than cold milkThe filter for cold filtration is situated in the pipe that connects the pasteurizer and the milk receiving tank or holding tank. The filter of this kind is positioned between the regenerator and the final heating portion of the HTST pasteurizer because warm filtration requires preheating. Periodically, the filter-bag needs to be cleaned. As a result, depending on the amount of foreign matter and the filter, the operation's duration may range from 2 to 10 hours .The pore size. Twin filters that are placed parallel are typically used to allow cleaning of one filter while the other is in operation. Because of this, processes can run continuously. We should be able to understand that filtration only eliminates the most obvious contaminants; it leaves behind microorganisms. As a result, it does not enhance the milk's ability to keep. In fact, if the filters are used for particularly lengthy periods of time before cleaning, bacteria may start to form in them.

7.1.7. Clarification

a. **Definition and objective**Clarification is another method for removing insoluble contaminants, particularly the finer ones, in place of filtration. It entails the employment of a clarifier, a centrifugal device. Clarification, then, is the process of centrifugally removing from milk the finer yet heavier particles such as somatic cells, dust particles, etc. Clarification cannot be regarded as an efficient method of removing bacteria, despite the fact that some bacteria are eliminated along with the extraneous material. In order to assure safety against pathogenic (disease-causing) microorganisms, one should be aware that it cannot be a replacement for a sufficient heat treatment.

b. **Principle of clarification**As we have learned, milk experiences a centrifugal force when it is placed in a centrifuge bowl between two adjacent rotating conical discs (in a stack of multiple discs). The comparatively lighter milk continuously flows inward and upward to the exit while the heavier dirt particles are ejected out into the sludge region surrounding the discs where they are gathered during the run. In a clarifier, skim milk and fat globules (cream) are not separated.
c. **Operation of a Clarifier :**In order to separate the milk from the dirt, raw milk is typically forced to flow under pressure through a distributor at the bottom of a revolving bowl, down the centre pipe, and onto the spinning discs. While the dirt is gathered in the sediment compartment, the milk is directed to the bowl's top discharge outlet. The clarifier is taken apart on a regular basis in order to empty the bowl of the sludge that has accumulated there. Depending on the size of the clarifier and the quantity of pollutants in the milk, the interval might be anywhere between one and eight hours.

7.1.8. SEPARATION OF MILK

According to our research, milk includes both fat and non-fat components, commonly known as solidsnot-fat (SNF). In contrast to the SNF, which are found as ionic solutions (such as specific salts), real solutions (such as lactose and whey proteins), or colloidal solutions (such as casein micelles) in the water portion of milk, fat is present as globules. Since the relatively big fat globules in milk are spread throughout the continuous aqueous phase (serum), milk is an example of an emulsion. Because they are lighter than other solids, fat globules have a tendency to rapidly separate from the serum (or skim milk), as seen by the appearance of a "cream" layer on top of milk that has been left undisturbed in a container for a few hours.The component of milk known as "cream" is high in milk fat but low in SNF. This implies that a sizable portion of the fat can be readily removed from milk in the form of cream, leaving the skim milk with very little fat remaining. Cream separation enables the producer to produce a variety of dairy products high in fat, including different varieties of cream, butter, ghee, etc. Cream separation further complicates it. Regarding the amount of fat and SNF in milk, adjustments can be made. It may be desirable to modify the composition of goods (see Section 4.5) in order to comply with the regulatory requirements for various forms of fluid milk.

7.1.8.1.**Methods of Separation** Two methods of separation of cream from milk are commonly used:

a. **Gravity separation and**

b. **Centrifugal separation.**

Both these methods rely on the basic principle of separation of two immiscible liquids having different densities, under the influence of gravitational or centrifugal force.

7.1.8.1.1. Gravity Separation As was already indicated, when milk is left to stand undisturbed for a while, a layer of cream (also known as "malai") forms on the top as a result of the fat globules that were initially spread throughout the bulk of milk rising to the surface. Gravity causes the lighter fat globules, which have a density of 0.93 g/cc at 20 oC, to rise to the top of the heavier serum, which has a density of 1.035 g/cc. Creaming may become obvious in as little as 30 minutes.

The rate of cream separation is inversely related to the viscosity of serum and directly proportional to the difference between the densities of the fat and serum as well as the square of the fat globule diameter. Thus, the highest creaming rate for a given sample of milk will occur when the density difference is greatest and viscosity is lowest. In turn, the temperature of the milk has an impact on both of these variables. The ratio of the density difference to serum viscosity increases as the temperature rises, encouraging the separation process. This increase is more noticeable between 10 and 30 degrees Celsius and considerably less so at 50 degrees Celsius.

However, cream separation by gravity is a highly laborious and ineffective process. For business objectives, it is not very useful. So, in the dairy sector, mechanised cream separation using a centrifugal machine is most frequently utilised. The use of a centrifugal separator, whether manually operated or powered by a motor, is common even for very small-scale separations involving, example, 10 to 20 litres of milk.

7.1.8.1.2. **Centrifugal Separation**Similar to gravity separation, this type of cream separation uses a spinning machine to generate centrifugal force as opposed to gravity as the driving force. Separation is significantly hastened because the latter force is much stronger than the gravitational pull. The centrifugal separator resembles the clarifier described in the previous section, except milk is fed into the separator bowl, which is holding a stack of conical discs, from the bottom, and it rises via holes anywhere between the discs' inner and outer borders. Because of the centrifugal force created by the rotating bowl, the milk between the discs tends to fly out from the centre.While the fat globules collect on the inside edge, the heavier skim milk fraction travels away and creates a layer on the outer border of the discs. The entering unmixed milk pushes the layers that are now separating outward and upward towards the top of the bowl. So, a cream separator has two outlets, one for skim milk and the other for cream, with the cream outlet being closer to the middle.

7.1.9. OTHER CENTRIFUGAL PROCESSES FOR MILK

Other than clarifying and cream separation, the principle of differential movement of heavy and light components of milk subjected to a centrifugal force has been used in a few applications. These comprise clarifixation and bactofugation.

7.1.9.1.Bactofugation

We may recall the milk clarifying, where it was claimed that some germs are also eliminated during the centrifugal removal of large dirt particles, etc. The 'bactofuge', a specialised high-speed discbowl centrifuge, increases the effectiveness of such bacteria removal. Bacterial spores, which are difficult to inactivate by heat treatment and are also heavier (or denser) than vegetative cells, can be removed from milk using a method known as "bactofugation." The bactofuge is a type of high-speed clarifier with discharge nozzles built into the bowl wall that operates at speeds up to 20,000 rpm.It can produce centrifugal forces of up to 10,000 g (g = gravitational acceleration). In the sludge space, bacteria from the milk that is being bactofuged are collected as "bactofugate." The majority of the bactofugate, which makes up about 3% of the feed volume, is made up of milk proteins and bacterial spores. 98–99% of the anaerobic spores are eliminated. Milk's bacterial spore count is reduced by more than 99.9% after a double-bactofuge process at 73° C.However, as bacteria in particular cannot be completely removed by bactofugation, the milk is typically pasteurised in order to guarantee consumer safety. The primary purpose for this pricey procedure is in the production of cheese, where the elimination of anaerobic (clostridial) spores from milk helps to prevent the issue known as "late blowing" in hard and semi-hard cheeses.

To increase the shelf life of milk when refrigerated, bacteria are removed. A procedure known as "Bactotherm" has emerged in order to eliminate the bacteria present in bactofugate and increase the efficiency of the procedure by using the milk protein present in it. Milk that has been clarified and standardised is bactofuged at 60 to 75 °C, and then it is pasteurised using the HTST method. The bactofugate is combined with cooled bactofuged milk for further processing after being deaerated in a vacuum chamber and sterilised at 130–140° C for 3–4 seconds using steam injection.

7.1.9.2.**Clarifixation**

A clarifixator is a device that uses the same basic idea as a centrifugal separator but adds a feature to reduce the size of fat globules in the cream fraction prior to mixing it with the skim milk being sent out. Because of the small-sized fat globules, the resulting milk, which is frequently referred to as "stabilised" milk, has a decreased tendency to cream following undisturbed storage. The 'paring disc' located in the cream tube at the top of the centrifuge has peripheral spikes or protrusions that cause the breakdown of fat globules.A fixed circular object known as a paring disc serves as a stationary centripetal pump. Before approaching the paring disc, the milk's cream separation strikes the protruding obstructions. As a result, the fat globules undergo extreme turbulence or shearing and shrink in size. (2 mm or less). The entering milk and the cream are then combined before being recirculated through the bowl. When the cream goes through the bowl discs a second time, the fat globules that have been suitably reduced in size won't be re-separated and will instead exit the separator through the skim milk outlet, discharging "homogenised" whole milk. Clarifixation hasn't been utilised significantly in the dairy business, though, due to its inferior effectiveness when compared to pressure homogenization.

7.1.9.3.Pasteurization

Modern dairy plant operations revolve around the pasteurisation process, which is essential to the production of many domestic and imported dairy products. Microorganisms can thrive easily in milk, and the proliferation of dangerous microorganisms can result in illnesses like typhus and tuberculosis. Pasteurisation renders milk safe for consumption by eliminating the pathogens that cause diseases to spread through milk. Pasteurisation is a term that honours renowned French scientist Louis 25 Pasteur. In general, it involves heating milk or its products to a temperature that virtually all the microorganisms present in them are destroyed while having little effect on the product's composition or qualities. Since poorly or inadequately pasteurised milk can result in an illness, it is crucial to keep an eye on the pasteurisation process. We will gain practical knowledge of the pasteurisation process from this unit. Let's examine the procedure.

7.1.9.3.1. **DEFINITION AND PURPOSE OF PASTEURIZATION** Fresh milk from healthy milking cows often has a low microbial burden. Milk can become contaminated during handling at the farm by a variety of microbes, primarily bacteria. The growth of microbes in milk is slowed down by quickly freezing it to below 4°C. Before being consumed as fluid milk, milk must undergo a prescribed process to ensure that all pathogenic germs are eliminated.

It is accomplished through the use of heat. One of the most crucial heat treatment procedures is pasteurisation. When used to describe market milk, the word refers to the procedure of heating each individual molecule of milk in correctly constructed machinery to a temperature of at least 63°C (145.4°F) for 30 minutes or 71.7°C (161°F) for 15 seconds (or to the temp-time combination that is similarly efficient). Milk is quickly cooled to 4°C and kept in cold storage where the temperature is kept at 4°+1°C.

"Pasteurisation is a process applied to a product with the objective of minimising any potential health hazard arising from pathogenic microorganisms associated with milk by heat treatment, which is consistent with minimal chemical, physical, and organoleptic changes in the product," according to the International Dairy Federation (IDF). As "universal" reference treatments, the IDF recommends pasteurising milk for 15 seconds at 71.7 °C, or 161 °F, or for 30 minutes at 62.8 °C, or 145 °F. Three aspects emerging from the definition are:

(i) level and degree of heat treatment,

(ii) minimum chemical, physical and organoleptic changes, and

(iii). minimum health hazards.

These are elaborated here.

i. **Time-Temperature Combination**The following time-temperature combinations are typically used to pasteurise fluid milk: 63 °C (145.4 °F), maintained there for at least 30 minutes, and 72 °C (161.6 °F), maintained there for at least 15 seconds. After that, the milk is quickly chilled to no higher than 4°C. There should only be one application of the chosen heat treatment.
ii. This indicates that the process of pasteurisation involves heating to a particular time-temperature combination and then immediately cooling to 4°C. ii. Reasons Pasteurisation of milk serves two purposes:

   a. To make safe for human consumption by destroying pathogenic microorganisms present in milk.

   b. To increase the quality of preserving it.

Mycobacterium tuberculosis is the heat-resistant pathogenic organism at pasteurisation temperature, hence it has been made into an index organism to ensure total milk safety. All other pathogenic organisms and other organisms responsible for milk deterioration will also be destroyed by any heat treatment that kills this organism. Even though pasteurisation may cause some bacteria known as thermodurics (heat resistant) to survive, the immediate cooling process slows down their growth, preventing them from producing spoilage like flavour taint or souring. Although the primary goal of heat treatment is to eliminate all pathogenic microorganisms that can infect humans, pasteurisation has two additional advantages, including the elimination of many spoilage microorganisms found in raw milk and the deactivation of some natural enzymes like lipases that can negatively impact the quality of manufactured goods by causing lipolysis, or the breakdown of fat into glycerol and free fatty acids.To be clear, pasteurisation does not take the place of cleanliness in the milk manufacturing process. Only raw milk from healthy cows that is clean, sweet, and has a low bacterial count should be subjected to pasteurisation.

7.1.10. **THEORY OF PASTEURIZATION**

We know that pasteurising milk by heating it to a specific time-temperature combination ensures the eradication of all pathogenic germs. Pasteurisation is defined as "the heat treatment applied to milk to destroy pathogenic organisms" in theory. The following is a detailed explanation of heat treatment or time-temperature combinations' process parameters:

(a) Limiting factors for heat treatment and

(b) Types of heat treatment.

7.1.6.1. Limiting Factors for Heat Treatment

The maximum and minimum temperatures for the pasteurisation procedure are determined by the thermal death point of tubercle bacilli and the start of cream line decrease, respectively. The lower limit for heat treatment is the thermal death time for tubercle bacilli. The negative effects on milk of commercial grade serve as a ceiling for the range of time-temperature combinations that can be utilised during pasteurisation. The cream line is typically used as the standard indicator of changes in the chemical, biological, and physical qualities of milk induced by overheating since it is the first quality to be impacted.

The time-temperature combinations that destroy all tubercle bacilli are taken as thermal death points.

Table 5.1 shows a number of thermal death points for tubercle bacilli.

Temperature		Time
^{0}C	°F	
100.0	212	10 seconds
93.3	200	20 seconds
82.2	180	20 seconds
76.7	170	20 seconds
71.1	160	20 seconds
68.2	155	30 seconds
65.6	150	2 minutes
62.8	145	6 minutes
61.1	142	10 minutes
60.0	140	10 minutes
57.8	136	30 minutes
55.6	132	60 minutes

These thermal death points can also be plotted on a graph to give a thermal death line.

Safety margin: To ensure that no tubercle bacilli are ever left alive following the proper normal operation of a pasteurizer, this additional heat treatment (period and temperature over the tubercle bacillus' thermal death point) is used. Undoubtedly, a much severe heat treatment would provide antibacterial effects that were more effective than pasteurisation. On the other hand, milk is not resistant to heating; excessive heating degrades the milk's flavour, nutritional content, and technological usefulness. It is also advised to combine a higher temperature and a longer holding time-temperature for HTST pasteurisation of dairy products with greater solids contents.

7.1.6.2. Types of Heat Treatment The holding and continuous heat treatments are related to the two pasteurisation techniques, i.e.

Batch, holding or Low Temperature Long Time (LTLT) method and

Continuous, High Temperature Short Time (HTST) method.

The milk is heated to 63°C using the batch method in a tank or vat with a hot water or steam jacket and agitators to keep the milk moving. It is then held for 30 minutes before being partially cooled in the batch pasteurizer. Surface/plate coolers are used for additional cooling. The majority of the time, this technique is utilised to process 5000 litres of milk.

Today, pasteurisation using the high temperature-short time (HTST) method is a prevalent practise everywhere. To heat, retain, and cool the milk, a plate heat exchanger (PHE) is employed. Milk is heated to a minimum temperature of 72°C, maintained there for at least 15 seconds, and then promptly cooled to a maximum temperature of 4°C.

7.1.11. HOMOGENIZATION: THEORIES AND PROCESS DESCRIPTION

Definition of Homogenized Milk

"Homogenised milk is defined as milk that has undergone a process to ensure that the fat globules are broken up to the point where, after 48 hours of quiescent storage, there is no visible cream separation in the milk and the fat percentage of the milk in the top 100 ml of a quart bottle (946 ml), or of the proportionate volumes in containers of other sizes, does not differ by more than 10% of itself from the fat percentage of the remaining milk as determined a

7.1.11.1. Process of Homogenizers

The designs of homogenizers differ based on the manufacturers because there are several types of homogenizer valves. However, a lot of the homogenizers used in the dairy sector were created using Gaulin's concepts. In essence, homogenizers only have two parts: a homogenising valve and a piston pump that produces high pressure.

Typically, the homogenizer pump is a positive displacement pump with at least three and occasionally five or seven pistons that fire sequentially to produce constant pressure. Poor homogeneity occurs as a result of the pulsing output and fluctuating pressure produced by single piston pumps. Although the piston seal rings are composed of a soft composite material, the pump block is typically constructed of stainless steel. 'Poppet type' or 'ball type' homogenizer valves are both used for milk. A poppet design offers a tight fitting seal and has comparatively large contact surfaces. 'Poppet' valves operate better with low viscosity liquids like milk if they are properly maintained. 'Ball' valves are appropriate for high viscosity liquids or suspensions with smaller seal areas because they may exert greater pressure on the much smaller seal surface particles.

Milk from the high pressure manifold enters the valve seat's centre. The valve seat's interior diameter is less than that of the manifold. Milk velocity increases when it enters the little space between this valve's fixed and moveable faces. An adjustable heavy duty spring provides a counterforce that keeps the gap open in the face of the feed pressure. High velocity gradients between the liquid and the surface of the homogenising valve cause shear effects.

Eddy currents within the flow are another source of turbulence due to the high velocity of the liquid in the valve. The pressure of a liquid that is moving past the valve at a speed of 200–300 m s-1 suddenly lowers to below saturation vapour pressure. This enables tiny bubbles to form for a brief period of time before dissolving. The milk jet then collides with an impact ring at a perpendicular angle. The disruption of the fat globules is a result of these impacts. Homogenizer valves are constructed from incredibly durable, corrosion-resistant alloys like stellite. In contemporary homogenizers, tungsten carbide and ceramic valves are frequently utilised by manufacturers to improve corrosion resistance.

7.1.12. UHT PROCESSING

DefinitionUHT milk is a product that is produced by heating milk in a continuous flow to a temperature more than 125oC for no less than two seconds and then packing it right away in sterile containers under aseptic circumstances. In India, UHT milk is typically treated for two seconds at 140 degrees Celsius.

7.1.12.1. Theoretical Basis

The death of microorganisms occurs when milk is heated. Only pasteurisation (71.7 OC/15 s) can completely eradicate some germs; however, some can withstand this heat treatment. Spores of Bacillus subtilis and Bacillus stearothermophillus can withstand high temperatures. Bacillus stearothermophillus spores are the most heat resistant of the two. As a result, it is regarded as an index organism for assessing the effectiveness of UHT processing.

Higher heating temperatures also cause unfavourable chemical quality changes in milk. The effects of browning are particularly significant. More browning and a resulting loss in flavour and quality are caused by higher heat load. The amount of time needed for practically all B. stearothermophillus spores to die is greater in the temperature range of

100-120o C. As a result, the product may brown more as a result. But if milk is heated to the UHT range of 135 to 150 degrees Celsius for only a short period of time, practically all spores may be killed, and browning would be at a minimum. Nutrient loss and overall quality loss will both be minimal. This means that a product prepared at these temperatures will be both microbiologically safe and of higher overall quality.

7.1.12.2. Types of Sterilization Plants

UHT plants come in two varieties: direct type and indirect type. The heating process in direct type plants involves combining the product and steam. In an indirect type plant, steam or hot water is used to heat the product without the two things coming into direct touch. In direct type plants, heating happens quickly and with low overall heat load, especially between 80 and 140 °C. Therefore, there are few changes in the product's quality. The rise in temperature in an indirect plant is quite slow. As a result, the product is under increased heat load. Comparatively more changes in chemical quality occur in indirect type plants than in direct type plants.

(i) Direct Heating Plant: There are two types of direct heating plants

(a) Injection type and

(b) Infusion type.

7.1.11.4. Injection type:

Milk is processed using a steam-into-milk system. The heart of this plant is the steam injector. Milk that has been heated to 80 to 90 OC enters the injector nozzles from one side. Steam enters the injector from the other side at a somewhat greater pressure. Milk is rapidly heated as vapour condenses after mixing with the liquid. Air cannot enter the holding tube because of the rapid condensation of steam. Inadequate heating is caused by air in the holding tubes. On the discharge side, there is no change in backpressure. Backpressure prevents product from boiling in the holding tube. Milk may get contaminated and improperly heated when it is boiled. There are numerous injector designs available.

7.1.11.5. Infusion type

This technique uses a milk-into-steam setup to heat milk. A chamber with pressurised steam makes up the processing unit. The top of the chamber is where milk enters. There are two further plans for milk distribution. In the first kind, milk pours into a hemispherical bowl, and the lid is sealed by a loose round disc. When the bowl is full, milk spills out and drips into the surrounding vapour. In an alternative setup, milk is distributed over a network of parallel, horizontal tubes. Milk runs like a thin film through the chamber of these tubes, which feature perforations along the bottom. Milk is heated to the desired temperature as it sinks to the bottom of the chamber.This method works well with liquids that are thicker and have smaller bits suspended in them.

7.1.11.6. Advantages and Disadvantages of Direct Heating System:

When steam from direct type heating systems condenses on the product while it is being processed, the product is diluted. The product is cooled in an expansion cooling vessel to eliminate the extra water present. non the expansion vessel, unwanted taste volatiles and incondensable gases created during heating are also eliminated non addition to the evaporating water. As a result, the product tastes better. Casein aggregates are formed as a result of steam injection, giving the product a "chalky" or "astringent" mouthfeel. To address such product flaws, direct heating systems are typically used. Aseptic homogenizers can safely homogenise the product after the last heating step.

Very quick heating (reaches sterilisation temperature in less than a second). The processing of thick or viscous liquid is also simple. Deposit buildup is minimal, allowing the plant to run longer between cleanings. During flash chilling, undesirable tastes are eliminated. Since oxygen is eliminated during chilling, flavour flaws caused by oxidation are postponed throughout storage.

(ii) The price of processing is expensive per unit of milk volume. Requires additional equipment (aseptic homogenizer and vacuum expansion chamber), which doubles the plant cost compared to indirect type plants. High amounts of energy are needed for heat. Consumption of water and power (which is 25–50% higher than in direct form) is considerable. requires a speciality boiler and steam for cooking. makes more noise while operating.

(iii) Indirect Type Heating System: There are three types of indirect heating systems: (a) Plate heat exchangers (b) Tubular heat exchanger (c) Scraped surface heat exchanger.

a. **Plate heat exchanger:**This is comparable to HTST plants' plate heat exchangers. Sequentially placed are a number of rectangular corrugated stainless steel plates. Then, to keep the plates together, they are mechanically tightened. The plates' corrugations cause turbulence, which increases heat transfer. High internal pressure is produced during processing at high temperatures. Therefore, materials that withstand heat, such as medium nitrile rubber or butyl rubber that has been resin-cured, are used to make the gaskets. Therefore, this plant's straightforward design and relatively low cost are among its main advantages. If there are more deposits, plates can be taken off and manually cleaned.

b. **Tubular heat exchanger:**Tubular heat exchangers come in two varieties: (a) concentric tube, and (b) shell and tube type. Two or three stainless steel tube lengths are stacked within one another to create concentric tube type heat exchangers. To keep the inner tubes concentric, a spacer is inserted between each one. These many tubes are assembled into a single unit and inserted into an exterior cylindrical casing. Simple cooling and heating are accomplished by means of two tube heat exchangers. The available heat transfer area doubles in a triple tube heat exchanger. It is typically utilised in the latter stage of cooling. It is also appropriate for processing thick liquids, which typically slow down the rate of heat transmission. Through the central annular space, the product moves. Inner tube and outer annular space are both passed through by the heating or cooling media.

In shell and tube type heat exchangers, an outer tube is constructed from 5-7 straight lengths of smaller tubes (10–15 mm internal diameter). A manifold connects the smaller tubes to the larger outer tube at both ends. The smaller tubes allow product to pass through. passing a heating or cooling medium through the space around them in a counter current flow. Tubular heat exchangers are mechanically very strong and can withstand even very high internal pressure generated during homogenization (200- 300 bar).

As a result, there is no longer any need to purchase an aseptic homogenizer to be used following the heating section. An regular homogenizer's high pressure reciprocating pump can be put in front of the sterile portion instead. The downstream side homogenising valve can be positioned anywhere, even after the final heating portion. The homogenization pump, not the valve, is the source of the product contamination issue. As a result, the product can be homogenised using tubular heat exchangers either before or after sterilisation, or even both times. To avoid the re-association of fat globules caused by high temperature processing after homogenization, fat-rich goods like cream require homogenization after final heating.

c. Scraped Surface Heat Exchanger (SSWE):

This particular heat exchanger is quite specialised. It consists of a cylinder with a jacket. Along the cylinder's axis, a shaft travels. At both ends of the cylinder, bearings support the shaft. Several scrapper blades are also carried by the shaft. Scrapper blades create turbulence as the shaft rotates while also physically removing the product from the wall's surface. The cycle then switches to the colder product to replace the heated one. SSHE is exclusively employed to heat extremely thick liquids. The energy conversion efficiency of SSHE units is quite low. As a result, processing is quite expensive.

D. Advantages and Disadvantages of Indirect Heating System:

It has a straightforward design and uses fewer pumps and controllers. 90% of the necessary thermal energy can be recovered. Aseptic homogenizer, which is highly expensive, is not necessary. It doesn't require cooking steam, so no special boiler is needed.

Plants of the indirect type are less loud. It has low initial capital requirements, and its running costs are likewise quite low. The rate of heat transmission in an indirect type heat exchanger is low. Lower acceptable product quality is the outcome of increased heat load. Because deposits form more frequently, plants need to be cleaned frequently. Deaerator is a piece of supplementary equipment needed to remove dissolved oxygen from milk.

7.1.12. Changes in Milk during Processing

Protein biological value is not diminished by UHT processing. Only a minimal (6-7%) amount of accessible lysine is lost. The casein micelle structure is altered by UHT processing. This slows the action of the rennet used to make cheese. (Direct processing: up to 50–75%, indirect processing: up to 70–90%) Serum proteins are denatured. Casein and denatured serum proteins interact, enlarging casein micelles. UHT milk appears whiter and more reflective as a result. Casein and aggregates of denatured serum proteins give the product a "chalky" mouthfeel. Milk fat does not undergo any physical or molecular change. Additionally, UHT processing has little effect on the overall mineral content. UHT milk has a comparable amount of vitamins to pasteurised milk. B-complex vitamin losses are limited to 10% or less.Up to 15% and 25%, respectively, of folic acid and ascorbic acid are lost during synthesis. Vitamins A, D, E, and K that are fat-soluble are unaffected by UHT processing. UHT fresh milk has taste with a hint of cooking. The SH (Sulphydryl) groups from the denatured serum proteins are what cause the cooked flavour.

7.1.13. Changes in UHT Milk during Storage

The storage temperature affects any alterations to the chemical, physical, or sensory properties of UHT milk. If the storage temperature is over 30 OC, changes happen quickly. During storage, browning reactions between lactose and protein advance. After three to four months, UHT milk stored at a higher temperature (>30OC) may start to turn a little brown. Before UHT processing, raw milk should be refrigerated to promote psychrotroph development. They release lipases and heat-resistant proteases. During storage, proteases that have survived UHT treatment work on proteins. The product becomes bitter as a result of the release of bitter peptides. After lengthier storage (more than six months), extensive proteolysis and other physico-chemical changes brought on by the interaction of proteins and ions during storage may result in thickening or sweet curdling, also known as age thickening. Lipases that withstand treatment at extremely high temperatures work on the lipid fraction. Free fatty acids with short and medium chains are liberated. Butyric acids in particular from short chain fatty acids help the product develop a rotten flavour.

Unsaturated fatty acids react with air in the product or packaging. Aldehydes and ketones are produced as a result of this autooxidation reaction. These substances give the product an off-flavor or oxidative rancidity. In the first few days, the cooked flavour in UHT milk goes away, and after this time, the milk tastes its best. A few weeks later, depending on the storage temperature, oxidised flavour flaws start to show up and get worse over time. Stale flavour is a common flaw in milk that has been kept for an extended period of time, which could be 3–4 months at $>30^{0}$C. This problem manifests as a number of chemicals that develop as the Maillard reactions in stored milk continue.

7.1.14. ASEPTIC PACKAGING

Aseptic packing is the process of filling pre-sterilized containers with UHT processed or sterilised milk while maintaining an aseptic/sterile atmosphere. This guarantees that the milk won't be contaminated after processing, extending the shelf life of the final product. Since aseptic packing systems are intricate, contamination must be avoided at all costs. Trial runs with sterile water are often carried out prior to beginning product packing. Critical components of the carton manufacturing and filling processes are thoroughly inspected. The packaging material's overall microbiological quality and seal integrity are adequately monitored. Typically, a good processing facility will allow one sterilised, packed, and sealed one-litre carton item to spoil out of every 5000.

7.1.11.1. Types of Sterilizing Medium Physical sterilisation mediums and chemical sterilisation mediums are the two primary categories that can be used to group sterilising mediums for aseptic packaging systems.

i. **Physical sterilisation mediums:** Steam or hot water under pressure is the easiest and most dependable sterilant for achieving a high level of sterilisation efficiency quickly. However, its usage in aseptic packing is limited to sterilising milk tubes, valves, and fittings that come into contact with the product.

ii. **Dry heat or extremely hot steam:** Hot air is typically used to sterilise the enclosed area where milk is filled. It is possible to apply air that has been heated to 300°C to the regions close to the electric resistances used to seal the packages. The milk filling tubes are also sterilised using dry air at 330–350 OC. For the purpose of removing any remaining H2 O2 (a chemical sterilant) from the package, sterilised air (180-200OC) is utilised.

iii. **Ultra violet radiation**: UV rays, with an ideal wavelength of 250 nm, are not a very efficient sterilising medium for aseptic packing equipment. This is primarily due to two factors: Intensity of radiation is not constant across the surface of the package (i) and bacteria that adhere to packages may be shielded by dirt or dust particles on the surface (ii). The employment of UV radiations as a supplemental sterilising medium is a result.

iv. **Ionizing radiations:** Gamma ray sterilisation is frequently used for packing goods that cannot survive high temperatures. Plastic laminates used in aseptic bag-in-box may typically be sterilised at 2.5 Mrad intensity.

v. **Chemical sterilization:** Mediums for Chemical Sterilisation Ethylene oxide has a gradual sporicidal effect. In order to lower the microbial burden on packaging films and shorten the time needed for final sterilisation, it is occasionally employed as a pre-sterilization agent.

vi. **Hydrogen Peroxide (H2 O2):**H2 O2's sporicidal action is ineffective at ambient temperature. However, sterilisation performance improves with higher application temperatures and concentrations. The most often used sterilant for aseptic packaging systems is H_2O_2. H_2O_2 is sprayed or dipped onto the surface of the box. The leftover H_2O_2 on the package surface can be evaporated using either sterilised hot air or infrared elements because its boiling temperature is just above 100 OC. Consequently, there is little H_2O_2 left to taint the product.

The IDF's safety recommendation states that the air H_2O_2 concentration in the packaging hall should not be higher than 1 ppm. Additionally, the residual content in milk should not be greater than 100 ppb immediately upon filling and should fall to 1 ppb within 24 hours. H_2O_2 and heat generated by a radiant heating element are the sterilising medium combination that commercial aseptic packing equipment employ most effectively. Additionally, some packaging techniques combine UV light and H_2O_2. Sodium hypochlorite and peracetic acid are two further sterilising agents that are hardly ever utilised in such applications. These substances leave acetic and chloride residues on the packaging, which may eventually infect the goods.

7.12.11. Type of Packaging Materials

a. **Metal container**: Condensed milk, viscous liquids, and chunk-in-gravy type goods are typically packaged in cans constructed of tin plate or drawn aluminium. These are pricey and inappropriate for inexpensive products like liquid milk. They take up a lot of storage and shipping space and are hefty. Empty cans are transported via conveyor to a sterilisation tunnel where they are sterilised using steam that has been heated to a high temperature using a gas flame at room temperature. The cans are subsequently moved to the product filling room. The can lids are individually sterilised, attached to the cans, and have their seams taped. Prior to filling, the can sterilising, filling, and sealing zones are sterilised using the same combination of superheated steam and flue gas that will fill them during filling. For many years, in-package sterilisation has been done with cans. Cans that are so associated with an outdated technology are not preferred by UHT milk producers who aim to impress consumers with the benefits of the new technology.

b. **Laminates/cartons:**A laminate is created by co-extruding various layers of flexible films made of various materials, such as paper, polyethylene, and aluminium foil. Since these materials have distinct qualities, such as water vapour transport and burst strength, they can be co-extruded to create the perfect packaging film. These laminates, which may have three, four, or five plies, are typically used for foods like milk, cream, fruit juices, soups, etc. Film rolls that can be installed on FFS (form-fill-seal) machines are used to deliver these laminates. As an alternative, laminated cartons are sold as premade blanks that are built into cartons before being filled and sealed at the top.

Plastic films: Co-extruded polyethylene films in black and clear colours are used to package UHT processed milk with a shelf life of two to three weeks. The coextruded film shields the product from oxygen but not from light. The operating temperature of the packaging equipment must not exceed 45 to 50 OC in the filling environment. Packaging film can also be made by co-extruding polyvinylidine chloride (PVDC) or ethylene vinyl alcohol (EVOH) with black or white polyethylene. A combination like this gives milk protection from both oxygen and light, extending its shelf life by up to three months.

Other forms of packaging materials : Additionally, aseptic packaging of value-added dairy products uses preformed containers in a variety of shapes and sizes. As less expensive alternatives, polyethylene or polypropylene blow-molded plastic bottles are employed. These, however, are clear and oxygen permeable. Better light and oxygen barrier multilayer materials have also been created. Polypropylene (PP) or polystyrene (PS) pre-formed plastic cups are becoming more and more common. Bulk filling bags are formed of laminates with three or four layers, one of which will be a barrier substance like ethyl vinyl alcohol (EVOH) or metalized polyester (polyester that has been coated with aluminium particles).

The filling valve bag is sterilised by gama-radiation (2.5 Mrad) and is then sealed. Bags continue to be sealed, keeping the internal surface sanitary. The sterilised bags are opened, filled, and sealed in an aseptic environment at the filling station. But before starting the filling process, the filler's entire product contact surface must be steam sterilised.

c. Description of the Packaging System

Form-fill seal (FFS) aseptic packaging equipment makes up the majority of the equipment utilised in the nation. The most common type of packaging material is a laminate made of polyethylene, paper, polyethylene, and aluminium foil. The packaging machine is equipped with a roll of packaging film. The film is in the shape of a strip that goes constantly downward and is given a cylindrical shape by a shaping roll. An overlapping longitudinal seal is created during heat sealing. Additional polythene strip is simultaneously heat bonded along the longitudinal seam's interior. This keeps the filled product from piercing the paper layer. The lower jaws of this continuous cylinder create a transverse heat seal as it descends. Instantaneously, the product is filled, and a second jaw top-seals the container. Different shapes might be supplied to the package depending on the type of machine. The brick-shaped packaging is the most popular. Fino packs are one of the modern inventions being employed for fruit juice packing. Some dairies have started packing milk in pillow packs to reduce expenses.

7.13.Milk Products:

When the natural components of whole milks have been altered by addition, removal, exchange, and/or treatment, the resulting milk is referred to as special milk. The market share of speciality milk varieties in the fluid milk business as a whole has increased dramatically in recent years.

Many milk plants in India are compelled to run below installed capacity, particularly during the lean season, as a result of the large seasonal variation in milk output. Furthermore, the cost of whole milk often remains elevated throughout the year. Recombined milk and low-fat toned milk manufacturing have dramatically lowered consumer milk prices and increased market supply.

Such diversifications allow the equipment and personnel of a market milk factory to be fully utilised throughout the entire year.

7.12.1. **FULL CREAM MILK**

i. Definition and Standards

Full cream milk is defined as milk, or a combination of cow and buffalo milk, or a product made from a combination of both, that has been adjusted or supplemented with milk solids to achieve a standard fat percentage of 6.0 and a solids-not-fat (SNF) percentage of 9.0. Milk with full cream must be pasteurised. A negative phosphatase test result is expected. It should be properly sealed after pasteurisation and stored in clean, hygienic containers to prevent further contamination.

7.13.2. TONED AND DOUBLE TONED MILK

Definition

Toned milk is whole milk that has had water and skim milk powder added to it. In order to produce it, whole buffalo milk is typically combined with spray-dried skim milk that has been reconstituted. According to the PFA Rules (1976), toned milk must have a minimum of 3.0% fat and 8.5 percent solids-not-fat nationwide, whereas double toned milk must have a minimum of 1.5% fat and 9.0% solids-not-fat nationwide.

History

D. N. Khurody, an Indian dairy pioneer, is credited with creating toned milk and with giving it its name. It was first made in 1946 under his direction in the Central Dairy of the Aarey Milk Colony and sold in Bombay. Calcutta, Madras, and Delhi were among the first places to produce and market toned milk. **Preparation**

The pasteurising vat/tank with an agitator is filled with the estimated amount of potable water. The agitator is kept running as the water is heated to 38 to 43 OC. At that time, a corresponding amount of spray-dried skim milk is progressively added, and the mixture is vigorously stirred until the milk completely dissolves. Now, a calculated amount of whole buffalo milk is added, and the mixture is vigorously churned once more to achieve homogeneity. The combination is then packaged and maintained at 5OC or lower until distribution after being filtered, pasteurised at 63OC for 30 minutes, then quickly cooled to 5OC. The detailed flow diagram for manufacture of toned and double toned milk is given below

Receiving water in pasteurizing vat

↓

Pre-heating (38-43o C)

↓

Addition of skim milk powder and mixing, and addition of whole buffalo milk and mixing

↓

Filtration

↓

Pasteurization (63o C/ 30 min)

↓

Cooling (5o C)

↓

Packaging and Storage (5o C)

7.13.3. STANDARDIZED MILK

i. **Definition**

A product with standardised milk has had its fat and/or solids-not-fat (SNF) content adjusted to a predetermined level. According to the PFA Rules (1976), everywhere across the nation, standardised milk for liquid consumption must have a minimum of 4.5% fat and 8.5% SNF. The standardisation can be carried out by either admixing with fresh or reconstituted skim milk in the right amounts, or by partially skimming the milk's fat with a cream separator.

7.13.4. SKIM MILK

i. Composition The average percentage composition of skim milk is given in the following table:

Constituent	**% (Average)**
Water	90.6
Fat	0.1
Protein	3.6
Lactose	5.0
Ash	0.7

ii. Utilization of Skim Milk for Making Different Dairy Products

A by-product of the cream separation process is skim milk. It is mostly employed to standardise milk and cream. The following table includes the names of widely produced dairy products as well as general guidelines for using skim milk:

Principle of Utilization	**Dairy Products Made**

1. Pasteurization	Flavoured milks
2. Sterilization	Sterilized flavoured milk
3. Fermentation	Cultured butter milk (Lassi) Acidophilus milk Bulgarian butter milk
4. Fermentation and concentration	Concentrated sour skim milk
5. Concentration	Plain condensed skim milk Sweetened condensed skim milk Low-lactose condensed skim milk Frozen condensed skim milk
6.Drying	Dried skim milk
7. Coagulation	Cottage cheese Bakers' cheese Quarg cheese Casein (edible)

7.13.5. RECOMBINED MILK

Recombined milk is the product created when fluid milk, skim milk powder, and water are combined in the right amounts to create butter oil (also known as dry/anhydrous milk fat). Other sources, like unsalted butter or plastic cream, can also be used to obtain milk fat. Recombined milk production is not now a reality, though.

7.13.6. RECONSTITUTED MILK

Reconstituted milk is defined as milk that has been made by blending whole milk powder with water (about 1 part powder to 7-8 parts water). Reconstituted milk is the primary source of milk supply in cities during the lean season.

7.13.7. FLAVOURED MILK

Milk that has had flavouring added to it is referred to as flavouring milk. When the "milk" is utilised, the finished product must have a milk fat percentage that is at least as high as the legal standard for market milk. However, the term "drink" is used when the fat content is lower (between 1% and 2%).

a. **Types of Flavoured Milk.**The main types of flavoured milk are as follows:
    iii. Chocolate milk/drink
    iv. Fruit flavoured milk/drink
    v. Sterilized flavoured milk/drink

b. **Preparation of Chocolate Milk Drink**

To prepare drinks, the milk is standardised to have 2% fat when it is received. After standardisation, milk is either pre-heated to 35–40 OC, filtered, or pre-heated to 60 OC, homogenised at 2500 pressure, and then clarified. Cocoa powder (1 to 1.5%), sugar (5 to 7%), and stabiliser (sodium alginate - 0.2%) are gradually added to the heated milk and mixed to thoroughly dissolve them. The mixture is then quickly cooled to 5 oC, pasteurised at 71 oC for 30 minutes, put in a bottle, and refrigerated (5 oC) until needed.

c. **Preparation of Fruit Flavoured Milk**

The process for making fruit-flavored milk is comparable to that of making chocolate milk or drink. Permitted fruit flavors/essences, permitted (matching) colours, and sugar are substituted for cocoa powder. Strawberry, orange, lemon, pineapple, banana, vanilla, and other flavours are frequently utilised. The following safety measures should be followed in order to get satisfactory results:

The fruit syrup shouldn't have any acid (citric or tartaric) added because doing so could cause milk to curdle. Avoid using sweet syrup in excess. The syrup's ideal sugar concentration ranges from 45 to 55 percent. 5 parts milk should be mixed with 1 part fruit syrup. Making sure that there is a tasty combination of sweet, fruity, and milky flavour (along with an appealing colour).

7.14. INDIGENOUS MILK PRODUCTS:

Every household uses milk products in one way or another. The preparation techniques for these foods, along with their nutritional worth, are described here.

7.13.1. CURDS/ YOGURT

It is a noteworthy milk item. Curd is created by combining a tiny amount of curd with warm milk and letting it sit for five to six hours. How can introducing a little bit of curd make all the milk turn into curd? Milk becomes curds when specific bacteria in the curd transform lactose into lactic acid. The lactic acid created is what gives the curd its firm consistency and sour flavour. For making curds, milk that is neither too hot nor too cold is required. This explains why making curds during the winter is difficult for you. We need to invert a large pan over it to prevent this and keep it warm. Milk and curd both contain similar amounts of nutrients. As a result, some individuals who are unable to consume milk may do so when it is in the form of curds. Curd is preferred over milk because it can be more easily digested, especially for conditions like diarrhoea and dysentery.

7.14.2. PANEER AND CHEESE

You may have seen that when milk is heated with a small amount of lemon juice or tartar added, the milk's solid components break into lumps, leaving a thin liquid in their wake. All the proteins, lipids, and vitamin A found in milk are included in this lumpy solid mass known as cottage cheese, or paneer. The liquid that remains after paneer has been separated is called whey. It contains advantageous vitamins and minerals like calcium, phosphorus, and vitamins B complex. Therefore, it is not recommended to throw away this priceless liquid. It is easy to incorporate into dishes with pulses, breads, curries, etc. You can also give this beverage to a child who belongs to a family member and may be having diarrhoea.

Paneer can be aged longer to produce several kinds of cheese. To achieve this, different microorganisms are added under different conditions. The resulting cheese has a strong flavour and is significantly more expensive than paneer. It is offered in little cubes and tins under a variety of brand names.

7.14.3. KHOYA

It is made by heating milk until it transforms into a solid mass with little moisture in a big open pan. It is a milk that has been concentrated. Khoya is easy to store for a long time because it has a low moisture content. In India, more milk is utilised in the khoya manufacturing process. Khoya is hard to find in the summer when milk is in short supply.

7.14.4. **CHHANA:**

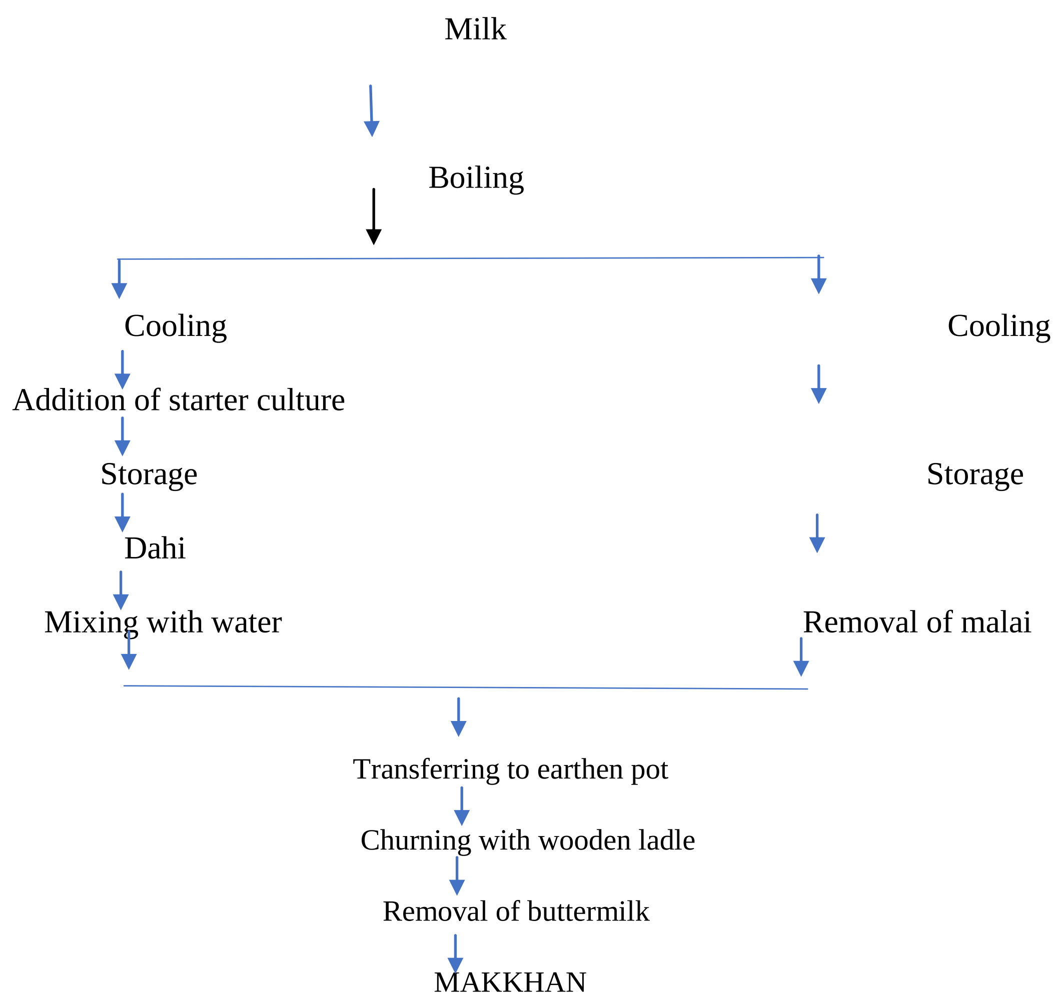
It is a well-known local milk product made by acid coagulating heated milk and then draining the whey. The product must, on a dry matter basis, have no less than 50% fat and no more than 70% moisture, in line with PFA. Chhana is used as a base and filler in the production of a variety of sweets, such as rasogolla, sandesh, ras-malai, etc. Cow milk chhana is more suitable for creating Bengali sweets than buffalo milk chhana because it has a moist surface, a light yellow hue, a soft body, a smooth texture, and a somewhat acidic flavour.

7.14.5.BUTTER

- **b. TRADITIONAL METHODS**
- **c. DESI BUTTER**

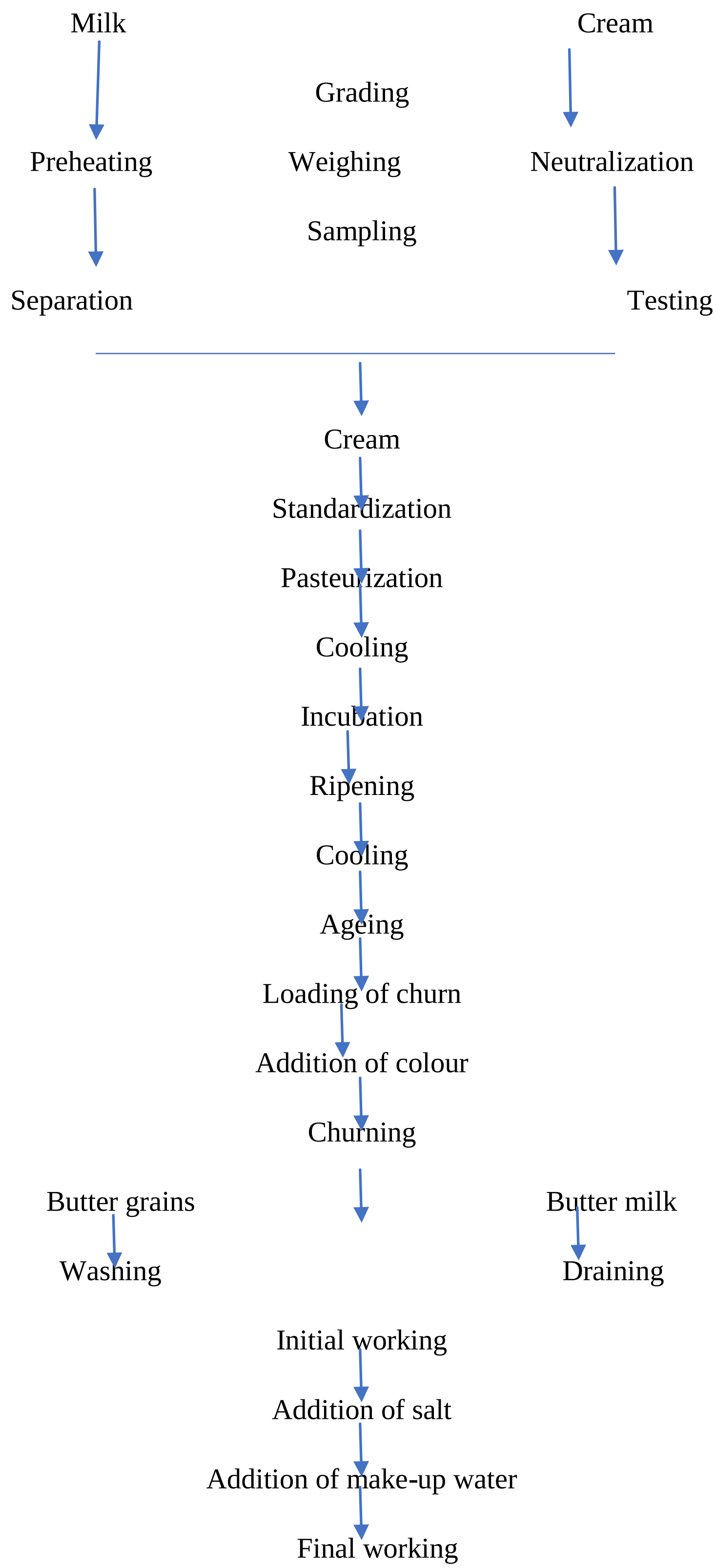
It is a freshly made butter that has been traditionally created by rural households and is known as Makkhan. Desi butter has a distinctive flavour and rich qualities. It is created by manually churning dahi or malai in an earthen pot using a wooden ladle sometimes referred to as a mathani.

Boiling, cooling, and culture are performed on cow, buffalo, or mixed milk using lactic starter culture (0.8-0.9% lactic acid) that was obtained from the previous day's batch. The next day, milk is kept at room temperature so that lactic fermentation can turn it into dahi. Dahi is combined with an equal amount of cold water the following morning and placed to an earthen pot. Following that, a wooden ladle (mathani) is submerged in dahi and physically swung around on a rope. The mathani is surrounded with rope at the centre. Makkhan grains start to develop after some time of constant stirring and float to the top. With the use of a ladle, these grains are skimmed from the surface and collected in an appropriate container. The process flow for producing Makkhan is depicted in Fig.1.



d. CREAMEY BUTTER

The steps involved in the manufacture of creamery butter are explained in Fig 5.2.



Butter

↓

Packaging

↓

Storage

Fig.2: Flow diagram for manufacture of creamery butter

1. **PREPARATION OF CREAM:**

For the production of creamery butter, the cream is obtained either by purchasing it directly from the producers or by separating the milk in the dairy plant. Fresh, sweet, and flavorful milk that is free of extraneous objects and acidity development is ideal. A centrifugal separation procedure is used to separate milk after it has been preheated to roughly 50°C.

2. **Neutralization:**

In order to make cream appropriate for churning and generate high-quality butter, the acidity of the cream is somewhat reduced. It lessens fat losses in buttermilk during churning, regulates the growth of unfavourable flavour, and enhances the butter's ability to retain. Prior to churning, the cream's acidity is neutralised with normal alkali solution, dropping it to 0.06–0.08%.

3. **Standardization:**

After neutralisation, the fat content of cream is standardised at 35–40%, which is thought to be ideal for making butter. More or less fat than this amount results in enhanced fat loss in buttermilk. With the addition of skim milk or water, depending on how buttermilk will be used, cream's fat content is standardised.

4. **Pasteurization:**

i. In order to achieve the following goals, it refers to heating each cream particle to an appropriate time/temperature combination.
ii. Destroy pathogenic microorganisms and make cream and the resulting butter safe for human consumption.
iii. Destroy other bacteria, yeast and mould, enzymes and other biochemical agents (enzymes) that may lower the keeping quality of butter.
iv. Eliminate some of the gaseous and taint producing substances.

5. **Ripening:**

Ripening is the process of allowing the acidity (fermentation) of the cream to grow with the aid of certain microorganisms. The goal of ripening cream is to provide butter with a pleasing, recognisable flavour and minimal fat losses in buttermilk. Butter that hasn't been salted keeps better while butter that hasn't been salted keeps worse. The starter culture must be added, the cream must be completely mixed, and it must be stored (incubated) at a specific temperature.

6. **Cooling and Ageing:**

Butter-fat can be found in cream as fat globules in both the solid and liquid states. The proportion of liquid fat rises as a result of the pasteurisation process, which transforms solid fat into liquid fat. More liquid fat in the cream prevents it from churning correctly. Therefore, it is crucial to cool the cream and keep it at a moderate temperature (5–10°C) for a while so that the melted fat partially resolidifies. After pasteurisation, cream is ideally chilled to 7-9°C in the summer and 10-13°C in the winter, and kept at this temperature for 15–16 hours, or at least for 2-4 hours. High cooling and ageing temperatures result in soft-bodied butter and enhance fat loss even if they shorten the churning time.The body of the resulting butter will be weak if the fat is not properly solidified, increasing the amount of fat that is lost to buttermilk.

The optimum temperatures of cooling and ageing depends on the following factors:

- Composition of fat
- Size of fat globules
- Fat percentage in cream Methods of Manufacture of Butter Butter 26
- Acidity of cream
- Period of ageing
- Temperature of churning

7. Churning:

Butter production is the aim of the churning process. The cream being churned should be easily churnable. It means that it should effortlessly and fully create sufficient firm grains of butterfat in the ideal amount of time (35–45 min).

The following factors may cause delayed churning, high fat losses in buttermilk, excessive foam production, defective butter production, etc. and thus cause difficulties in churning of cream:

i) Excessive hardness of fat
ii) Small size fat globules
iii) Excessive thin cream
iv) Overloading of churn
v) Excessively low temperature of churning
vi) Abnormal cream

8. Loading the churn:

The butter churn needs to be well cleaned and sanitised before use. It is then filled with the aged cream that has been cooled. If there are any lumps, they should be mixed by stirring or straining. Cream should be served at 7-9°C in the summer and 10-13°C in the winter. Preferably, the amount of cream in the churn should be a little less than its rated capacity.

9. Addition of colour:

The churn door is closed after the churn is loaded and butter colour is added to the cream. The addition of colour causes butter to remain a consistent shade of yellow all year round. Per 100 kg of butter fat, the amount of added colour typically ranges from 0 to 250 ml. The pigment should be persistent, non-toxic, oil soluble, without an off flavour, and intense.

10. Operation of the churn:

In the first five to ten minutes, the churn is turned a few times before the churn vent or air vent is opened once or twice. It enables the gases and air to escape.

11. Draining of buttermilk:

After the churning procedure—which typically lasts 35 to 45 minutes—is finished, the churn is stopped, and the buttermilk is emptied by opening the drain valve situated at the bottom. To ensure that the butter-milk is entirely drained, it is crucial to stop the churn in the correct position. In order to keep the tiny grains that come out with the buttermilk, a sieve is also employed.

12. Washing:

It contributes firmness, gets rid of the loose buttermilk stuck to the butter grains, and lessens the strength of some off odours. Removing any remaining buttermilk lowers the amount of curd in butter and enhances its shelf life. Washing is done using water that is 1-2°C below the churning temperature of cream and in an amount equal to the drained buttermilk. The churn is churned a few more times after the addition of the wash water before the water is poured off. Usually, one washing is plenty. Use only high-quality water that is bacteriologically and chemically safe.

13. Initial working:

The churn is rotated a few times after the wash water has been drained to help the butter form a solid mass. Additionally, the extra or loose moisture is expelled and drained out.

14. Salting:

Salting is done to promote butter overrun, improve butter quality, and improve taste. Butter can be salted using one of three techniques: dry salting, wet salting, or brine salting.

15. Moisture control:

According to legal standard, the butter must not contain more than 16% moisture.

16. Removal of butter from churn:

Manual labour, gravity, or mechanical techniques are all used to accomplish this. Compressed air (3–5 psi) and soft butter are needed for the mechanical method of removal.

7.14.6.PREPARATION OF MARGARINE:

The basic method of making margarine today consists of emulsifying a blend of oils and fats from vegetable and animal sources, which can be modified using fractionation, interesterification or hydrogenation, with skimmed milk which may be fermented or soured, salt, citric or lactic acid, chilling the mixture to solidify it, and working it to improve the texture.[8][26] Margarines and vegetable fat spreads found in the market can range from 10% to 90% fat, depending on dietary marketing and purpose (spreading, cooking or baking). The softer tub margarines are made with less hydrogenated and more liquid oils than block margarines.[27]

Three types of margarine are common:

- Bottled liquid margarine to cook or top dishes.
- Soft vegetable fat spreads, high in mono- or polyunsaturated fats, which are made from safflower, sunflower, soybean, cottonseed, rapeseed, or olive oil.
- Hard margarine (sometimes uncolored) for cooking or baking.

Technically, margarine is a form of shortening, but the commercial products sold as "shortening" are generally uncolored and do not taste like butter.

7.14.7. SALAD DRESSINGS

According to Parker et al. (1995), salad dressings are high-fat emulsions that are typically stabilised by high shear in the presence of egg yolk as the main emulsifier. A spoonable dressing called mayonnaise by definition has 75% oil in it. In order to create a spoonable dressing with roughly 40% oil, starch pastes were next used. The most popular dressings available today can be poured, have a wide variety of oil levels, and are mostly stabilised by xanthan gum (Franco et al., 1995).

In order to comprehend both ingredients (Smith, 1977; Paredes et al., 1988) and processing (Parker et al., 1995), model food systems have been utilised.

7.14.8. MAYONNAISE

The egg yolk is combined with the water and one-third of the vinegar to make mayonnaise, which is then churned until it reaches a high viscosity. This "cold process" should only be conducted at temperatures under 5°C. The remaining vinegar and oil are then gradually added.

b. MAYONNAISE MANUFACTURING PROCESS

Production of commercial mayonnaise frequently involves two steps. Oil and the other necessary ingredients are coarsely scattered (20-100 m) in a pre-mix tank in the first phase. The resulting pre-mix is then fed from the tank to an emulsifying device in a flowing stream to precisely subdivide the oil into droplets with an average size of 1 to 5 m. A high viscosity oil-in-water emulsion is produced by the partition of the oil into tiny droplets that form a densely packed (i.e., space-filling) structure. Industrial mayonnaise benefits from having a high viscosity since it increases product stability.

The oil volume percentage and droplet size distribution of the final product have a significant impact on the physical structure that is created during mayonnaise manufacturing. The consistency and rheological characteristics of mayonnaise are governed by the tightly packed structure of the oil droplets. Higher viscosities emerge from the mayonnaise structure's increased density as droplet size decreases. Therefore, mayonnaise equipment that can produce smaller oil droplets is required if firmer mayonnaise is wanted.

7.14.9. PROCESSING OF GHEE –

a. Pre-stratification Method:

Using a batch or continuous churn, aged cream with a fat content of 38 to 40% is turned into butter. The butter is then moved to a butter melter, where it melts at 80°C. For 30 minutes, this molten butter is left unattended in a ghee kettle or boiler at an ambient temperature of 80 to 85°C. The stratification of material that creates the three separate layers of ghee occurs here. Impurities and denatured protein particles (curd particles) accumulate on the top layer and float. Clear fat makes up the middle layer, while the buttermilk serum at the bottom contains particles other than fat that make up 70% of the butter and convey 80% of the moisture.

b. Cream - emulsification method:

The idea behind this continuous ghee-making process is the de-emulsification of cream fat from the oil-in-water phase to the water-in-oil phase. Using a centrifugal cream separator and clarifixator, milk is split into the 40% fat cream in this procedure. In a concentrator that uses centrifugal force, this cream is further concentrated. In the clarifixator and concentrator, mechanical de-emulsification of fat is carried out. Fat concentrate is flavoured and has the majority of its moisture removed using a scraped surface heat exchanger. Ghee residue is eliminated by an oil clarifier after the moisture remnants have been removed from it in a vapour separator.

c. Hazards in Ghee Processing:

1. **Physical Hazards**

- An extraneous matter like Foreign Particle, dust, dirt, glass, stone etc. due to low storage, environment.
- Very fine particles in ghee due to improper settling.

2. **Chemical Hazard**

- • The lingering cleaning chemical may cause probable cross-contamination. residues brought on by dirty pipelines.
- Polymer Migration from packaging Material.
- Cross-contamination due to residue of cleaning chemicals.

3. **Biological Hazard**

- Coliforms, Clostridium Botulinum, Salmonella, E.coli, Yeats & Mold / Aerobic spores due to improper cleaning.

7.14.10. PROCESSING OF KULFI:

Kulfi is a common indigenous frozen treat offered by street vendors across this nation. It has a slightly brownish to yellowish hue, a compact body, an ice texture, and a nutty, caramel-flavored flavour. It is well-liked throughout India's northern, central, and western regions. In the conventional method, milk is continually stirred and thickened in a shallow pan. Towards the end, ingredients like sugar, almonds, essence, and colour are added. In metallic moulds, concentrated mass is poured and then frozen in a solution of ice and salt.

A. PROCEDURE OF KULFI MAKING

(i). TRADITIONAL METHOD:

1. Standardised fresh, clean whole milk has 5% fat and 9% MSNF.

2. Cane sugar is added at a quantity of 10% by weight of milk.

3. The milk is then reduced to roughly half its original volume and concentrated in a shallow pan while being constantly stirred.

4. Starch at 3% or sodium alginate at 0.15 percent by weight are added and combined after concentration.

5. The mixture is then chilled for around 6 hours to 40 F.

The mixture is then supplemented with chopped nuts, such almonds, pistachios, and cardamom (0.5%), flavour, and colour.

7. The mixture is then put into 80 ml aluminium cones, sealed, and set in an earthen pot with an ice and salt combination.

8. To prevent the production of big ice crystals, the contents of the cone should be shook often when freezing.

(ii). INDUSTRIAL METHOD

1. The materials used in the industrial process are the same as those used to make ice cream: milk, cream, skim milk powder, sugar, and stabiliser. The combination, which only contains a

little quantity of sugar and no stabiliser, is diluted with water while the fat:MSNF ratio is kept at 1.4:1. Typically, there is 16% fat in the final product.

2. The necessary amount of components are added to an open steam kettle, and the mixture is cooked while being vigorously stirred.

3. After the combination has been concentrated roughly twice, the stabiliser Manufacture of Kulfi is added, which has been mixed with a little amount of sugar (1:3 parts by weight), and the heating and agitation are continued until the mixture has been concentrated three times.

4. The concentrated bulk is quickly cooled and frozen to a 20–30% overflow in a batch freezer.

5. In the freezer, chopped nuts like pistachios and almonds are added after flavour and colour.

6. The frozen mixture is quickly poured into the moulds with freezing pockets.

7. In a brine tank kept at a temperature of -23 to -30 C, wooden sticks are added and the mixture is hardened.

8. The moulds are then put into a tank with lukewarm water to defrost the bars so they may be removed from the frozen spots with ease.

9. Following this, the bars are wrapped in paper, stacked in corrugated boxes, and kept in a cold storage facility until distribution.

7.14. CHILLING AND STORAGE OF MILK

Receiving, cooling, and storing milk are the first operations carried out at a dairy facility. Filtered and chilled raw milk is pumped from the dump tank to the storage tank. In order to ensure consistency in milk processing processes and prevent any quality degradation during the holding and processing periods, storage tanks are designed to retain milk at low temperatures.A cooling facility or dairy facility may receive the milk in cans. Milk is refrigerated after being removed from the cans, then it is kept in storage tanks. Milk is kept in storage tanks, either raw or pasteurised. In the tank, milk can be kept refrigerated (5°C) for up to 72 hours between receiving and processing. The milk storage capacity should typically.

7.14.1. Objectives of Storage Tanks

• To keep milk at a low temperature so that it doesn't lose any quality before being processed or turned into a product.

• To make raw milk supply more plentiful and ensure homogeneous composition

• To permit continuous operation during processing and packaging

• To make it easier to standardise the milk

7.14.2. Storage Tank

Tanks for storage make it possible to hold milk for longer periods of time. They must be made to be simple to clean and sanitise, preferably using the CIP method. A stainless steel inner shell, an insulation layer, an outer jacket, and the appropriate fittings for inspection, control, and cleaning make up storage tanks. To be able to maintain the proper temperature throughout the holding period, the tanks should be insulated or chilled. Insulation materials include glass wool, thermocol, corkboard, foam glass and polystyrene. In the lower parts of the tank, where the insulations may bear a portion of the load, corkboard or foam glass is employed. The right amount of agitation is necessary for homogenous mixing, but it must be mild enough to avoid churning and air incorporation.

To keep milk at the proper temperature, chilled water circulation systems are available in many storage tanks. A manhole that is round (diameter 450 mm) or oval in shape must be installed on all closed-type tanks in order to allow access to the inside for cleaning and inspection.

A curved filling pipe that directs the milk towards the wall is utilised to ensure foam-free milk entry. Filling the tank from below, or using the lowest output pipe, is preferable. Typically, the storage tanks for ordinary pasteurised milk or raw chilled milk are found on the first floor. This enables milk to be fed through pasteurizers or even filled by gravity. Large silos, typically > 1.0 lakh litres in capacity, are only placed on the ground level of dairies today. They are excellent for keeping skim milk in storage to feed the powder factories. Rectangular tanks are less popular in the dairy business than cylindrical ones due to the difficulty of cleaning their sharp corners. Second, in rectangular tanks, the agitation effect does not extend to the corners.

7.14.3. Types of Storage Tank

On the basis of their shape and other characteristics, storage tanks can be categorised.

a. Insulated storage tanks
Simply put, the milk is stored in these tanks at the temperature at which it is filled. The temperature of milk tends to rise with time depending on the quality of the insulating material in most situations. These tanks are composed of an inner shell made of stainless steel, a layer of insulation (glass wool and thermocol), and an exterior jacket made of mild or stainless steel.

b. Refrigerated tanks

It contains built-in refrigeration systems that allow for on-demand cooling of milk that has been stored. An additional benefit of these tanks is their ability to maintain the proper temperature. In refrigerated tanks, the cooling medium (chilled water or brine solution) is circulated in the hollow area between the inner and outer shells.

c. Horizontal or vertical tanks

Tanks that are horizontal need less headspace but more floor area than tanks that are vertical. Horizontal tanks with capacities between 5,000 and 15,000 litres can be utilised to handle minor amounts. Milk is currently kept in vertical silos, which are tanks with a capacity of one lakh litres or more. Outside the building, these upright, cylindrical tanks are present. The same discharge valve that is positioned near the bottom of these silos is used for milk feeding.

7.17. Chilling Equipments

7.15.1. Surface cooler

Either a standalone unit or a cabinet type is possible. The latter is made up of two or more separate pieces that have been compactly put together and contained in a cabinet. Typically, it is greater than those employed at the farm or chilling facility.

7.15.2. Plate chiller

It is frequently used to cool milk at chilling centres at a rate of 5000–60,000 litres per day. They are effective, small, and simple to clean. The gasket plates of a chiller are firmly fastened between the plates. These plates are set up such that milk runs down one side and a cooling agent, typically cold water, runs down the other. The cooled water and the milk run through different plates against each other.

It aids in the fast chilling of milk by facilitating the efficient passage of heat to the cooling medium. The milk is cooled to 4°C as it travels from the plate cooler to the insulated storage tank. There must be a mechanical refrigeration system (IBT).

7.15.3. Internal tubular cooler

By enabling the effective transfer of heat to the cooling medium, it helps milk chill quickly. As the milk moves from the plate cooler to the insulated storage tank, it is chilled to 4°C. A mechanical refrigeration system (IBT) is required.

7.15.4. Vat/tank cooling

For batch cooling, particularly of small quantities, it is appropriate. It consists of a tank inside another tank, with the cooling medium being circulated there either by a pump or by main pressure. The milk is stirred using an agitator to facilitate quick chilling.

7.18. CONCLUSION

Special milk physically functions and seems like liquid milk. Special varieties of milk can be produced by modifying, eliminating, exchanging, or manipulating the natural components of milk. Unique milk types include full cream milk, toned milk, double toned milk, standardised milk, skim milk, mixed reconstituted milk, and flavoured milk with flavours like chocolate and strawberry. All distinctive milk variants are required to follow certain requirements listed in PFA standards. Additionally, there are certain advantages to making such distinctive milk. Special milks require special manufacturing techniques and additives to manufacture.

Butter can be categorised as desi, creamery, culinary, table, etc. depending on how it was made. Makkhan, another name for Desi butter, is prepared on a small scale by hand churning dahi or malai in an earthen pot using a wooden laddle known as a mathani. Either it is consumed at the household level or it is sold at the neighborhood market. Fresh cream obtained by centrifugal separation of milk in a dairy factory is used to make creamery butter using a batch churn or continuous butter producing machine. To create high-quality butter with a longer shelf life, acidic cream with a high acidity (0.06–0.08% L.A.) is neutralised using common alkali. The process of turning cream into butter typically results in some fat being lost to buttermilk.

Various indigenous products are also prepared with milk like khoya ghee, cheese, curd, channa, and kulfi or ice-creams. Storage of milk products is also very important. Various storage tanks are used for creating chilling temperature for increasing the shelf life of milk and milk products. Several hazards are also discussed to improve the end products quality in this unit. Milk products has a great industrial value and facilitates large-scale production of various products and helps in increasing the per capita income of the country, and providing employment to a large sector of people.

KEY WORDS:

Pasteurization : Pasteurization of milk is done by heating milk to at least 63OC for 30 min, or 72OC for 15 sec. After pasteurization milk is cooled to 5OC or below.

Pre-heating : Pre-heating of milk refers to heating before the operation which follows immediately. The usual temperature of pre-heating is 35-40OC, and the equipment used may be a plate or tubular heater.

Filtration : Filtration removes dirt, dust, suspended and foreign particles by the straining process.

Cooling : Milk is generally chilled to 5OC or below and stored cool till it is used, to prevent deterioration in its bacteriological quality.

Standardization : Standardization of milk refers to adjustment of fat and solid-not-fat of milk to fulfill the legal requirements before sale.

Homogenization : Homogenization refers to the process of breaking fat globules in order to prevent formation of cream layer upon storage and enables easy digestion of milk

Sterilization : Sterilization of milk refers to subjecting milk to heat treatment at more than 100OC for sufficient period of time, so as to destroy almost all spoilage causing microorganisms.

Neutralization : It is the process of partial reduction of acidity of cream, by using standard alkali in order to make it suitable for churning and produce good quality butter.

Standardization : It is the process of adjusting the fat content of cream to 35-40%, which is considered optimum for butter production.

Ageing : It is the process of storage of cream at low temperature at least for 2-4 hr for crystallization of liquid fat.

Ripening : It is the process of storage of cream at suitable temperature (21°C) after addition of starter culture like Streptococcus lactis, Streptococcus cremoris, Streptococcus, diacetilactis, Leuconostoc citrovorum or dextranicum for the development of acidity.

Salting : The purpose of salting is to improve keeping quality, enhance taste and increase over-run in butter. The methods of salting includes dry salting, wet salting and brine salting.

Yield : It refers to the quantity of butter obtained from a known of quantity of fat taken for churning.

Buttermilk : It is the by-product obtained during butter production. It is classified as sweet cream buttermilk, sour cream buttermilk and desi buttermilk.

Check your progress:

1. Give two reasons for pasteurizing the milk.
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2. Describe the time-temperature combination normally used for milk pasteurization.
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3. List three different ways in which you commonly use:

a) Milk
b) Curd
c) Paneer
d) Khoya
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1) Differentiate between Desi and Creamery butter.
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2) Give the maximum limit of addition of salt to creamery butter.
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3) Give the qualities of colour added to butter.
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4) Name the colours used in butter.
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5) Give the optimum temperature for churning of cream.
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6) Explain ageing of cream. ....
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7) Describe ripening of cream. ....
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8) Give the optimum temperature for flavour producing organisms to grow in cream during ripening.
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9) Name the flavouring compound in butter.
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10) Explain the term double standardization.
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11. Why is chilling of milk essential within stipulated time after production?

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12. How does chilling arrest the microbial growth and enhance keeping quality of milk?

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13. what do you mean by tonned milk and skim milk.

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14. Write the process of flavoured milk.

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BLOCK III: MEAT, FISH AND EGGS, ADDITIVES AND PRESERVATIVES

This block deals with the detailed processing techniques of meat fish and egg, also with food additives and food preservatives. This block consist of two units i.e. Unit VIII and Unit IX. Unit VIII deals with Meat, Fish and Eggs, nutritional composition and processing techniques of meat fish and poultry. Unit IX deals with Food additives and Food Preservatives.

UNIT VIII: MEAT, FISH AND EGG PROCESSING

Structure:

Meat, Fish and Egg Processing

8.0. Chemistry of processed meats,

8.0.1. Ageing and tenderising,

8.0.2. curing,

8.0.3. smoking and freezing of meat,

8.0.4. fresh storage of meat.

8.0.5. Fish preservation and processing.

8.0.6. Dehydrated egg powder and frozen egg,

8.0.7. egg storage,

OBJECTIVES

After reading this unit, you will be able to:

- list advantages of meat processing; describe different methods of processing;
- explain the principle of different methods of processing;

- classify meat products; and
- state different ingredients used for processing of meat.

8.0. INTRODUCTION

We have learnt in the previous Unit that, of the 15 main groups of food commodities mentioned by FAO, nine are of plant origin, four of animal origin, and two of both plant and animal origin. The foods of animal origin consumed by humans comprise meat and offal, milk and milk products, eggs, fish and other sea foods. Such items are concentrated sources of protein, fat, vitamins and minerals which greatly contribute to human nutrition, health and development. As a rich source of proteins, minerals and vitamins, these foods of animal origin act as body building foods, protective foods and regulatory foods.

Animal proteins are high quality protein i.e. containing all the essential amino acids. These are considered as superior protein than that from plant origin. The Expert Group of Indian Council of Medical Research in 1990 has recommended that 1gm protein is required per kg of body weight. Majority of this protein comes from meat, milk, egg and fish. Meat, in its broadest definition, is animal tissue used as food. Most often it refers to skeletal muscle and associated fat. It may also refer to non-muscle organs, including the ‘offal’ (organ meat/variety meat or all edible portions other than the muscle).

This may include heart, liver, kidney, tongue, brain, thymus, pancreas, diaphragm, cheek meat, testes, udder, ox tail, edible fat, tripe (meat from the four stomach of ruminants- rumen, reticulum, omasum and abomasum), weasand (meat from oesophagus), etc. All processed or manufactured products which might be prepared from these tissues are also covered by this definition.

Eggs are a common food and are important in many branches of the modern food industry. Hen’s egg is the most commonly used egg. Eggs from duck, goose and quail are occasionally used. Ostrich, pheasant and emu eggs are perfectly edible but less widely available. Egg proteins are highly utilized in body i.e. biological value of egg is very high.

Fish as a food indicates the edible parts of freshwater and saltwater dwelling, cold blooded vertebrates with gills. Shellfish, such as mollusks and crustaceans fall into the broadest category of fish. Fish yield high amounts of proteins, vitamins, minerals and polyunsaturated fats. Fish proteins contain all the amino acids required by the body. It is high in Omega 3 fatty acids, which are heartfriendly, regular diet of fish is highly recommended by nutritionists. Fish is a very good source of B complex vitamins and fish liver oil is an exceptional source of vitamins A and D.

8.1. Food Safety

Meat is a highly perishable food item. A variety of factors can cause meat to spoil including micro-organisms, exposure to air, and improper handling and freezing techniques. The most common cause of meat spoilage is the deterioration of meat caused by micro-organisms (bacteria, yeasts, and molds). Meat tissue surfaces carry considerable bacterial loads. Meat is considered spoil when it is unfit for human consumption. Spoil meat may be inedible due to unpleasant tastes and odors or may be unsafe for consumption especially when micro-organisms have caused the meat to spoil. Meat and meat products that have not been handled or stored properly should not be consumed even if they have no apparent indications of spoilage. To evaluate food safety risks in meat animals and meat products, preproduction (on-farm) and processing (in-plant) technology have to be distinguished. Pre-harvest covers the live stage of the animal till its slaughter

Animals are most likely to be exposed to infections, parasitic infestations and residues while still alive on the farm. The pre-slaughter care and management of the animals in farms, during transport and in the slaughterhouse are important from pre-harvest food safety perspective. Stressful transportation of livestock and poultry, deprivation of feed and water, over crowding, and exposure to high or low temperatures deleteriously affect meat quality. Major sources of contamination are other diseased animals, feed, fodder, water and handler. Wild fish are grown and caught in their natural environment (seas, rivers and lakes). Such catches harvested from the nature sometimes could pose health problems associated with high mercury content and harmful micro-organisms and algae. The farmed fish raised in man-made conditions are frequently found to contain higher levels of contaminating toxins such as polychlorinated biphenyls (PCBs) and dioxins which are present in their feed.

8.2. Chemistry of processed meats,

8.2.1. Ageing and tenderizing

To prevent microbial decomposition, carcasses are aged by being kept at a temperature just above freezing. The tenderness and quality of the meat are also improved throughout this procedure. Inosine (inosine monophosphate), a breakdown product of ATP (adenosine monophosphate), is primarily responsible for the improvement in flavour. The generation of hydrogen sulphide, ammonia, actaldehyde, acetone, and di-acetyl as a result of protein and fat breakdown during ageing, together with a rise in free amino acids, also contributes to the development of the distinctive meat flavour. The modest proteolytis that occurs in the cytoskeletal proteins is what causes the relief in soreness. The proteolysis brought on by ageing, which results in the tenderness associated with ageing, is causally caused by calpains.

Ageing processes in various dietary animal species

Cattle : 14 days

Sheep and Goats : 7 days

Pigs : 5 days

Chicken : 2 days

Techniques that are frequently used to shorten ageing periods include calcium chloride infusion into meat or electrical stimulation of carcasses (which must be done within half an hour of slaughter for effectiveness).

8.3. CURING

The process of curing meat involves adding salt (sodium chloride), sugar, and nitrate or nitrite to the meat, which causes the flesh's pigments to change into the distinctive cured meat pigments that give the meat its distinctive colour and flavour. Although it was initially developed as a method of meat preservation, the technique of curing meat is now prized for adding organoleptic aspects to the cured goods. The requirement for meat preservation by curing alone has decreased with the development of effective and ubiquitous refrigeration. The meat packing industry is concerned with the following qualities in addition to characteristic colour and flavour: preservation, tenderness, and yield.

Curing Substances

Chloride of sodium

potassium or sodium nitrate

Salt nitrite

Acetic acid, Monosodium glutamate, and Sugar

The Curing Effect of Spices and Vinegar

8.3.1. Salt

By dehydrating the body and changing the osmotic pressure, salt prevents bacterial development and eventual deterioration. Chlorine, which is poisonous to organisms, is produced when it ionises. The cells become more sensitive to CO_2. It obstructs the function of proteolytic enzymes. The content and storage temperature of sodium chloride both affect how effective it is. According to reports, hams can have salt levels as high as 3% and bacon as low as 2%.

8.3.2. Sugar

By balancing out salt's harsh and hardening impacts, sugar softens the products.It interacts with the amino groups of proteins and causes browning of the products during cooking, which improves the flavour of the cured meat. In order to reduce the amount of browning that occurs while cooking, sugar alternatives have been employed in bacon cures. Through dehydration, it serves as a preservative.

8.3.3. Both nitrates and nitrites

Nitrosyl hemochromes, which are produced by nitrates and nitrites, cause the development of the desired pink coloration. In situations when nitrates serve as a reservoir for nitrites, both nitrates and nitrites are employed. Because nitrate increases the oxidation-reduction potential, it is better for aerobic than anaerobic species. They prevent the development of germs that cause food illness and deterioration. The ability of nitrite to stop the growth of the Clostridium botulinum bacteria has been amply demonstrated. They prevent rancidity from forming.

Since nitrate and nitrite are harmful, finished products cannot include more than 200 ppm of either one alone or in combination.The European Directive 95/2/CE (1995) permits 150 ppm of nitrite (if present alone) or 300 ppm (if present alone and nitrate are present), and residual values must be fewer than 50 ppm (if present alone) or 250 ppm (if present alone and nitrate are present).Bacon curing agents must adhere to stricter regulations in order to lessen the production of nitrosamines. Nitrate is therefore no longer allowed in any bacon, whether it is pumped and/or massaged, dry-cured, or immersion-cured.

8.3.4. Nitrosamine-

Nitrous acid, which is created when nitrite breaks down, reacts with secondary amides to create nitrosamine. The carcinogenicity of nitrosamine has been established. In a few cases, they have been kept apart from cured meats. The component that governs their development is currently being investigated, although the solution is not yet known.

8.3.5. Phosphates

Alkaline phosphates are utilised to boost the finished product's yield and water binding capability. Reduce the amount of shrinking that occurs when cooked smoked items to increase the percentage of usable products that are delivered to consumers by reducing the amount of purge or cook-pout in canned goods.

Licenced phosphates include

1. Tripolyphosphate sodium
2. Hexametaphosphate sodium
3. Acid pyrophosphate of sodium

4. Phosphorus dehydrate
5. In sausages, only sodium acid pyrophosphate is allowed.
6. The 0.5% legal limit for residual phosphates added to final products.

8.3.6. Ascorbates/Ascorbic Acid

Ascorbates participate in the conversion of metmyoglobin to myoglobin, hastening the healing process. Nitric oxide production from nitrous acid is increased by the reaction between ascorbates and nitrites. Extra ascorbate functions as an antioxidant and stabilises flavour and colour. Ascorbate's antioxidant qualities not only stop the growth of rancidity but also stop the colour of sliced meats from fading when exposed to light.

Federation Laws authorise

For the pickle used to cure primal cuts, use 75 oz of ascorbic acid or 87.5 oz of sodium bicarbonate per 100 gallons of pickle and 0.75 oz of ascorbic acid or 0.875 oz of sodium bicarbonate per 100 pounds of sausage emulsion.

MSG, or monosodium glutamate-To improve the flavour of several items, it has been utilised. Its use in cured meat products offers few benefits. It is added at a level of 0.1%.

8.4. SMOKING

After curing, the meat is desalinated by soaking it in water for about an hour at 20 degrees Celsius. It is then dried and put in the smoke house. Along with curing, smoking is done. The cured products are put in an airtight smoke house, and smoke and heat are both administered at the same time. Smoke is produced using hard wood logs and sawdust. Depending on what is available and how it is used, different types of wood are used in different countries. The items take on a distinctive colouring and smell after smoking. The smoking process lasts for three days at 85°F (29.5°C). It slows the oxidation of fat. Bacteriostatic effects are produced by both the deposition of components and the lowering of water content.

8.4.1. METHODS OF SMOKING

a. Natural air circulation- This technique makes use of a fire pit made to burn logs, sawdust, or a combination of the two. Dampers' opening and closing aid in regulating air volume.

b. Air-conditioned smoke house- This has mostly superseded smokehouses that used natural air. This approach enables considerably greater control over smoking, cooking temperature, and shrinkage as a result. The fan controls how much air is circulated. This home often regulates humidity and smoke velocity.

c. Continuous smoke house- This was created specifically for the manufacturing of frankfurters and is a component of the continuous process system.

8.4.2. EFFECT OF SMOKING ON NUTRITIVE VALUE

The final internal temperature of smoked gammon must be at least 58°C, according to federal regulations. From the start of the cooking schedule to the finish, many processors maintain a single temperature schedule of 38 - 82°C. Hams are thoroughly cooked at 66 to 68°C, and Frankfurters, bologna, and bread products are cooked to an internal temperature of around 68°C.

a. Influence of smoking on nutritional value

- While the amino groups are affected by the smoke's carbonyl group, the proteins' sulphydryl groups are more likely to be affected by the phenols and polyphenols.
- Both of these processes can reduce the nutritional value of proteins by reducing the amount of accessible amino acids, particularly lysine.
- Thiamine can also be damaged to some extent by smoking.
- The fat-soluble vitamins should be stabilised by wood smoke's antioxidant qualities, which are also predicted to keep smoked meat products' surfaces from oxidising.
- Smoking therefore offers some benefits.

b. **Nature of smoke**

- Smoke comprises two phases: vapour and particles.
- The more volatile elements are found in the vapour phase, which also gives smoke its distinctive flavour and scent.
- Furthermore, the components of tars and polycyclic hydrocarbons, both of which are undesirable in smoke, are significantly reduced when the particle phase is removed by precipitation.

8.5. FREEZING OF MEAT

- It is well known that unless properly maintained, meat will not last for a long time.
- The simplest technique of preservation is by using the cold method, and the invention of refrigeration only sped up the development of the meat industry. Today's meat industry is founded on effective refrigeration.
- Refrigeration is the term for low-temperature preservation.

- The process of refrigeration entails removing heat from a body and lowering its temperature to that of the environment.
- Depending on how much heat is removed from the product, refrigeration can be divided into chilling (refrigeration over the product's freezing point) and freezing (refrigeration below the product's freezing point).
- Meat can be kept in a condition that is close to its natural state with effective refrigeration for times long enough for commercial use.
- The technique slightly modifies the meat's weight, look, and flavour without adding or taking anything away.
- Because the activities of food-borne microorganisms can be slowed down or stopped at a temperature just above freezing and are typically stopped at sub-freezing temperatures, the use of low temperature preserved foods is justified.
- All microorganisms' multiplication halts at a temperature of -8°C and doesn't start again unless the temperature is restored to a suitable level.
- The loss of the available water as ice, which occurs between 3.5°C and -10°C and removes roughly 70% to 94% of the water, is the key factor in why bacteria cannot grow at or below freezing.
- The life activities of organisms that cause spoiling are inhibited at low temperatures, which is another reason.
- Low temperatures prevent the action of natural autolytic enzymes in flesh meals.
- These occur because all of the metabolic processes carried out by microbes are catalysed by enzymes, and the pace of these reactions is temperature-dependent. The reaction rate does not diminish as the temperature drops.
- The relative humidity of the air in the atmosphere as well as the temperature affect the surface growth of mould on meat.
- Psychrophiles are defined as creatures that thrive in cold environments.
- Pseudomonas is home to the majority of psychropylic bacteria, with smaller proportions of those belonging to the genera Achromobacter, Flovobacterium, Alcaligenes, Micrococcus, and others.
- Species and strains of moulds and yeasts from many different genera can grow at the temperature of a refrigerator.
- Mesophilic moulds include those from the genera Penicillium, Mucor, Cladosporium, Torulopsis, Candida, Rbodotorula, and others.
- Moulds must have a high relative humidity in order to grow, and if one is not there, they will wither away.
- The relative humidity and temperature must therefore be kept as low as possible to prevent the growth of mould.

8.5.1. CHEMICAL CHANGES IN CHILLED MEAT

- Due to the chemical alterations that occur after slaughter, there is a very small degradation of muscle protein by endogenous enzymes or by those of microbes.
- The flavour of the meat can be described as stale, making it unappealing but not disgusting. The meat smell gradually becomes more noticeable but never unpleasant.
- Because fat rancidity, even to a minor extent, is unpleasant, the chemical changes that occur in fat rather than in muscle affect beef storage life more.
- Therefore, the length of storage depends on the condition of the fat.
- While a carcass' lean muscle may still be developing in flavour, alterations in the fat content could make the meat repulsive and unsellable.
- The retail butcher removes the kidneys and fat of home-killed beef shortly after slaughter since rancidity is most likely to occur there particularly in hot weather.
- These are always taken out of EEC-approved establishments before weighing.

8.6. FISH PRESERVATION AND PROCESSING.

Fresh fish accounts for about 65-70% of all fish landings in India. This is a result of both India's population's strong demand for and taste for fresh fish, as well as insufficient storage facilities for the fish. Consequently, the majority of the fish is consumed locally market. A fraction of the catch is transported and chilled, but the distribution area is small, and unmarketed fish is frequently wasted. Therefore, it is crucial to conserve the fish for the reasons listed below:

a. It can be transported to far-off locations,
b. preserved for a longer time, and made available during off-seasons.
c. To command a higher price
d. To minimise waste and loss

Thus, all techniques and tools for ensuring prolonged storage of the good while ensuring its safety for consumption are included in preservation. You will learn in this section how processing techniques aid in the preservation of fish and other aqua products, but first you must comprehend how fish spoils.

8.6.1. SPOILAGE OF FISH

Without going into specifics of spoiling, you had read in the previous lesson about the composition of fish and post mortem alterations. You might remember that autolytic degradation and microbiological spoilage occur after rigour mortis, which is one of the crucial stages after fish death. Enzymes are the change-causing agents in both autolysis and bacterial deterioration. Because the fish body after death lacks a defence mechanism, bacteria enter deeply into the tissue. Enzymes that work on fish tissue are secreted by them. The fish's natural enzymes do not increase, but if the conditions are right for growth, bacteria proliferate.As their population increases, more enzymes are secreted, which can quickly break down the tissue and produce undesirable byproducts. You may remember from the last unit that fish has a high moisture content, a high protein content, and a high non-protein nitrogenous component content. All of factors encourage the development of proteolytic bacteria, which can break down protein as a growth substrate and do so by producing enzymes. The microbial enzyme activity causes a cascade of modifications that lead to the production of flavorful and odoriferous chemicals. The hydrogen sulphide synthesis of amines and free ammonia from amino acids causes an initial sour smell that eventually turns into a sulphur smell. Trimethylamine oxide (TMAO), an odourless molecule, is transformed to Trimethylamine (TMA) in marine fish and a few freshwater species, which binds to fatty substances to produce a smell.Additionally, bacterial enzymes are responsible for this. The tissue becomes softer as a result of protein degradation, and a lot of water that was previously attached to proteins dissolves and leaks out along with the disintegrated proteinaceous materials.

In addition to altering flavour and odour, the microbes also have an aesthetic impact on fish, causing the slime on their skin and gills to shift from being clear and aqueous to murky and discoloured. Scales often start to fall off the body, the skin gets dull, and the eyes darken. The fish's look has completely changed. The fish goes through three different states: fresh, stale, and rotting. The degree of rotting determines whether or not the fish may be eaten.Microorganisms, particularly bacteria, are the main cause of raw fish's degradation, which results in the formation of an offensive scent and flavour.

Pathogens are organisms that can harm the body of the consumer (host) either directly or indirectly. They consist of both toxic and infectious microorganisms. The toxic ones cause fish to become toxic. When consumed, contaminated fish can have negative effects. If pathogens are present, they spread quickly along with the microorganisms that cause seafood deterioration.They might cause the customers significant issues. Therefore, it is crucial that infections do not enter the raw material, and even if they do, they should be regulated.

8.6.2. PRESERVATION OF FISH

You now see how crucial it is to keep spoilage microbes under control in order to keep fish from degrading. Microorganisms can be managed by preventing their admission, physically removing them, physically destroying them, killing them, or limiting their growth by fostering unfavourable conditions.

Each of the methods for limiting microbial growth mentioned above has been explained in detail.

a. Keeping Microorganisms from Entering

In water, fish are found. There are many microorganisms in water that can easily enter a fish's body. The gills, which constantly pump water, are another place where the germs can enter. Along with various food particles, a lot of microbes enter the intestine. Therefore, it is challenging to prevent microorganisms from entering fish bodies.By making sure that all surfaces that come into touch with fish are hygienically cleansed, it is possible to prevent human diseases and spoilage microorganisms from entering the fish after it has been landed.

Getting Rid of Microorganisms Washing is a necessary step in the physical eradication of microorganisms. Fish surface filth and slime are removed during washing with clean, drinkable water, which lowers the microbial load. Fish surfaces are scrubbed to get rid of grime and slime, which aids in getting rid of microorganisms. Bacteria that are present in the gills and intestine are removed.

b. Killing Microorganisms

Microbes can be killed by heating or cooling to a point where the organisms are obliterated. Antibiotics, radiation, and chemicals have all been found to be effective for these purposes. These killing agents may only be used under the restrictions that they must not make the fish inedible and must not have a negative impact on the consumer.

c. The management of microorganisms

Water and nutrients are essential for the growth of bacteria and other microbes. If the temperature, oxygen content, and pH are favourable, they grow quite quickly. If any of these conditions are not met, a microorganism either cannot grow or develops very slowly.

Microorganisms come in countless varieties, each with unique needs. Thus, the goal of preservation is not to rid something of all microbes but to stop known diseases and spoiling microbes instead. Water activity is a unit of measurement for the volume of water that is available for bacterial activity. In a nutshell, water activity (aw) is the ratio of fish vapour pressure to pure water vapour pressure. Aw must be within a favourable range, similar to pH and temperature, for the microorganisms to flourish.

8.7. IMPORTANT COMMERCIAL METHODS

The foundation of any preservation technique is the use of some way to control or stop the growth of microorganisms. A combination of preservation methods is used when one approach proves to be too severe and renders the result unusable. This section will look at some significant commercial fish preservation techniques.

8.7.1. Freezing

In essence, freezing is the process of removing heat from an object until it reaches a temperature below zero and takes on a hard consistency as a result of the solidification of its water content and the hardening of organic tissue. The preservation technique of freezing is based on two ideas: (1) rapid exposure to low temperatures is fatal to microorganisms because it inhibits their ability to develop; and (2) The majority of the free water in food solidifies, making it impossible for bacteria and other microbes to function. Low temperatures also have the benefit of slowing down the activity of autolytic enzymes. As you are aware, every 10 degrees of temperature rise causes a roughly 2-fold increase in the pace of biological reaction, and the opposite occurs when the temperature is dropped. Because of the decline in the biological reaction rate, bacteria are less active.

The freezing procedure is not a preservation technique by itself. It just serves as a method for preparing fish before storing it at an appropriate low temperature. Low temperature has preservation effects. Washing, dressing, adding ingredients as needed, and setting up the food for feeding are all steps in the freezing process.Frozen food must be produced as soon as possible to ensure quality.

8.7.2. DIFFERENT TYPES OF FREEZERS

By exposing the fish to extremely cold surfaces or liquid, freezing can be accomplished. The mechanism of heat transfer, refrigerant temperature, and freezer design all affect how efficiently heat is transferred. However, a fish freezer is chosen by taking into account its functional and financial viability.

1) An air blast freezer

By continuously blowing cold air over the fish, freezing is accomplished. Since air is cooled by a primary refrigerant like evaporated liquid ammonia or cliloroflouro carbon (eFC) flowing through the pipes through which air is blown, air is the secondary refrigerant. The speed of the air flow affects how quickly things cool.

There is a limit to how fast the air can move because doing so could dry out the product.There are two types of air blast freezers: batch and continuous. A batch type air blast freezer has all of the material placed into it. Up until the freezing is complete, cold air is blown. Vanes and guides in the insulated chamber control the air flow's direction, ensuring a more or less uniform freezing. In the continuous kind, the fish go over a conveyer belt and through an insulated tunnel into which cold air is forced from the opposite direction. In a batch-style air blast freezer and roughly 10-15 m/sec in a continuous-style air blast freezer, the air speed is maintained.

Advantages and disadvantages of air blast freezers

The greatest flexibility in accepting fish of any unusual form and size is provided by air blast freezers. This kind of freezer requires minimal capital investment and processing staff. The result is slow freezing. In this freezer, losses from dehydration are substantial, uniform freezing is difficult to maintain, and regular defrosting is required to maintain efficiency.

(ii)Contact plate freezer

In this kind of freezer, the fish or its packaging is in direct touch with metal plates that have been adequately cooled. Heat transfer is improved by sandwiching the product between two metal surfaces. Pumping icy refrigerant through the plates cools them.The plates can be moved with the help of hydraulic pressure to create a compact product and the close contact required to ensure efficient heat transmission through conduction.

a. Advantages and disadvantages of plate freezers

The freezing occurs more quickly than with an air blast freezer thanks to the excellent heat transmission.

In the case of a plate freezer, the product's and the package's original shapes are preserved. In addition to reinforcing the block and protecting fish during subsequent handling, the water supplied to fill the air gaps also lowers the risk of dehydration and oxidation during storage. The preparation and handling required for plate freezing make it a labor-intensive operation. Additionally, it needs to be defrosted because air pockets frequently stay and cause insufficient freezing.

(iii). Irrigation freezing

Here, freezing is achieved either by submerging the fish in a chilly liquid refrigerant or by misting the product with a refrigerant. A primary refrigerant, such as liquid nitrogen or liquid CO2, or a secondary refrigerant, such as brine that has already been chilled by a primary refrigerant, is the fluid that comes into contact with fish. The term cryogenic freezing is used to describe freezing using liquid nitrogen or liquid carbon dioxide, whereas the word immersion freezing is more or less limited to freezing using brine, or salt solution. These two liquids swiftly remove the fish's heat, causing ultra-rapid cooling, at temperatures of -196°C and -78°C, respectively.

a. Advantages and disadvantages of plate freezers

Due to dehydration, weight loss from these freezers is minimal. As there is no contact with oxygen, there is no oxidation of fat as there would be in an air blast freezer. They take up relatively little room and can quickly freeze a significant amount of food. The main drawback of these freezers is that they are best suited for high-value fish due to their high production costs per kg of fish. Additionally, improper handling of the refrigerants results in waste and may be dangerous to the handler.

8.8. FREEZE DRYING

The method of freeze drying combines freezing and drying. Fish is first frozen, and then the ice that has formed is sublimated by low pressure that has been created. Ice can be turned into vapour through a process called sublimation without turning into water. When both the pressure and temperature are below 4.58 mm of Hg, this occurs. Sublimation is essentially a drying process because it involves the removal of water. Once the ice has been sublimated, the items can be stored in airtight, moisture-free bags rather than having to be frozen because they can easily reabsorb moisture. When the ice melts during sublimation, it removes heat from the product, causing it to chill even further. In order to keep the sublimation process going, more heat must be provided. Accelerated freeze drying is the term used when the sublimation process needs constant energy input. Low water activity and a lack of oxygen (items are often packed in an inert gas) are what cause the preservation.

Both benefits and drawbacks of freeze drying

More than 90% of the moisture is removed from food during freeze drying, leaving it light and convenient for air travel. To avoid reabsorption of moisture, it must be packed with inert gas. 95% of the moisture that is removed can be reabsorb, but the result is still porous and fragile. Squeezing out the water that was reabsorbed is simple.If the material is enclosed in a firm container, it keeps its original shape. The amount of nutrients lost during freeze drying is little.

8.9. DRYING AND SALTING

Drying and salting are both preservation techniques, and they are frequently combined in traditional processing techniques. Prior to drying, smoking, and marinating, salting may be used.

8.9.1. Salting

A series of procedures known as "salting" involve exposing fish to salt and allowing it to permeate the fish. The entire salting procedure entails washing, cleaning, gutting, and placing the fish in a container with the salt. The salt permeates into the tissues and forces moisture out because of the osmotic difference it creates between the interior and outside of the fish tissue.When this occurs, it is referred to as a salt strike. The elimination of water, which results in a low water activity in the tissue, is the basic idea of salting. Numerous bacteria, both harmful and spoilage, are present but are unable to thrive when there is little water activity and salt present.

The fish is therefore kept.The process of salting results in a significant water loss. A good preservation requires salt that is of the proper kind and fine enough grade to dissolve with ease.

The preservation is effective until the tissue's salt content reaches the bare minimum required to stop microbial development. Additionally, fish can be salted by submerging it in a saturated salt solution.This method has the advantage of creating close contact between the fish and the salt solution, which prevents oxygen from oxidising the fat and giving off a rotten odour.

8.9.1.1. Factors affecting the salting period

The length of time needed to salt a fish depends on the following variables:

a. thickness of the fish; the greater the thickness, the longer the time needed to salt

b. salt concentration of the brine; the greater the difference between the salt concentration of the brine and the fish, the faster the salting rate.

c. Salting temperature: The rate of salting increases with temperature.

d. Salt quality: The degree of contaminants and fineness of the salt have an impact on the safting rate.

Finer particles are quickly dissolved and come into closer contact with the product.

Impurities negatively impact the rate of salting.

a. The standard of salted fish

The majority of known viruses are unable to flourish in well-salted fish. On it, a small number of halophilic bacteria can thrive and cause discolouration. If the salted fish is kept in a humid environment, halophilic moulds may also develop. The salted fish needs to be cleaned, rehydrated with water, cooked, and then consumed.

b. Drying

One of the oldest methods of preserving fish is drying. The idea at play here is lowering the quality of the fish's water below what the bacteria that cause spoiling need.

Another highly traditional and age-old method of preserving fish is to dry it after salting.For rehydration, dried fish must be soaked in water for a large amount of time before being cooked and eaten. There are two different forms of drying: mechanical drying in an oven and natural drying in the sun (sundrying). Drying products under hoover has gained popularity recently because the quality of the finished goods is higher.

c. How drying is accomplished

The difference between the vapour pressure of water on fish surface and that in the air causes moisture to be pushed out of the fish. Until the vapour pressure is balanced, the water molecules diffuse into the atmosphere.Low air vapour pressure means that there isn't much moisture in the air, but it may still contain moisture. Air movement facilitates drying by accelerating the absorption of moisture from the fish. When there is an air flow, the equilibrium stage is attained earlier even though the final drying level is the same. Thus, the mechanical drying process establishes a low moisture environment and regulates the flow of air to ensure rapid drying.

Quality of dried fish (The quality of dried fish cannot compare to that of fresh fish. It has a familiar flavour that some people appreciate. It lacks succulence and occasionally has a rubbery feel, even after being rehydrated.

The fish must have finished drying before being stored. Poor-quality dried fish will have yellow discolouration, softening of the belly, and a putrid scent.

8.10. SMOKING

Similar to drying and salting, smoking is a traditional preservation technique. Fish is preserved by smoking, which gives it a delightful flavour thanks to the smoke's unique flavour and keeps it fresh thanks to several chemical components in the smoke. Fish is typically eaten raw, without further preparation.

Cold smoking and hot smoking are the two sorts of smoking procedures. Fish that is cold smoked is often salted and dried before smoking. Therefore, the impacts of smoke, low water activity, and bacteriostatic smoke components that are ingested by the fish are what cause the preservation effects. Depending on the size of the fish, the smoking takes place for 8–24 hours at a temperature of 20–30°C.Fish is partially cooked when it is hot smoked. Adding dry salt or utilising concentrated salt solution results in light salting with a final salt concentration of 1.5–2%. Following a fresh water rinse, the fish are hung in the smoking chamber. Sawdust, wood shavings, and logs are used to create smoke. The chamber is kept at a temperature of 80 to 100 °C.

The process of smoking causes the fish to become dry, kills the majority of pathogens and spoilage microflora due to heat, and then coats the fish in a variety of bacteriostatic compounds. Fish is preserved as a result.

8.10.1. Composition of smoke

The aqueous distillate of smoke is made up of several different components. The alcohols with 2-3, 4 carbon atoms, the aldehydes such as formaldehyde and acetaldehyde, the ketones such as acetone and methyl ethyl ketone, xylene, and phenols are among the various organic acids and their esters. The preservation effect is caused by the presence of phenols, organic acids, and aldehydes, particularly formaldehyde. A substance called 3-4 benzopyrine, which is likewise a component of smoking, is thought to be carcinogenic.

8.11. PROCESSING OF EGG AND EGG PRODUCTS

8.11.1. Introduction

For use in commercial, foodservice, and domestic settings, eggs are processed and packaged into egg products. These include frozen, dried, and speciality items as well as chilled liquids. Shell eggs are placed in cold holding areas when they are brought to the breaking plant. They are washed in water that is at least 20 degrees warmer than the temperature of the egg before breaking, and then sprayed with a sanitizer. When they are shattered, they may be damp but not wet.

8.11.2. Classification of Egg Products

For usage in commercial, food service, and domestic settings, eggs are processed to create convenient forms. The following categories apply to egg products:

1. Refrigerated liquid products

Egg yolks, egg whites, and various white-yolk combinations

2. Frozen products

Egg white, egg yolk, whole eggs, salted whole egg, sugared yolks, salted yolks, and egg white

3. Dried/Dehydrated products

Whole egg or yolk solids, spray-dried egg white solids, instant egg white solids, and free-flowing whole egg or yolk solids (with sodium silicoaluminate added as a free-flowing agent) are all examples of egg solids.

4. Specialty products

scrambled eggs that have been freeze-dried, frozen precooked items such egg patties, fried eggs, crepes, and egg pizza, etc.Commercial bakers, food producers, and the foodservice sector prefer egg products to shell eggs because to their many benefits, which include convenience, labour savings, minimum storage needs, simplicity of portion control, and product quality, stability, and uniformity.

As per egg product inspection act all egg processing plants must follow below conditions: Pasteurization of all egg products is mandatory. Shell eggs used for egg products must be clean and of edible interior quality.

8.11.3. Frozen Egg Products

These include separated whites and yolks, whole eggs, blends of whole eggs and yolks or whole eggs and milk and these same blends with sugar, corn syrup or salt added.

8.11.4. Production of frozen egg

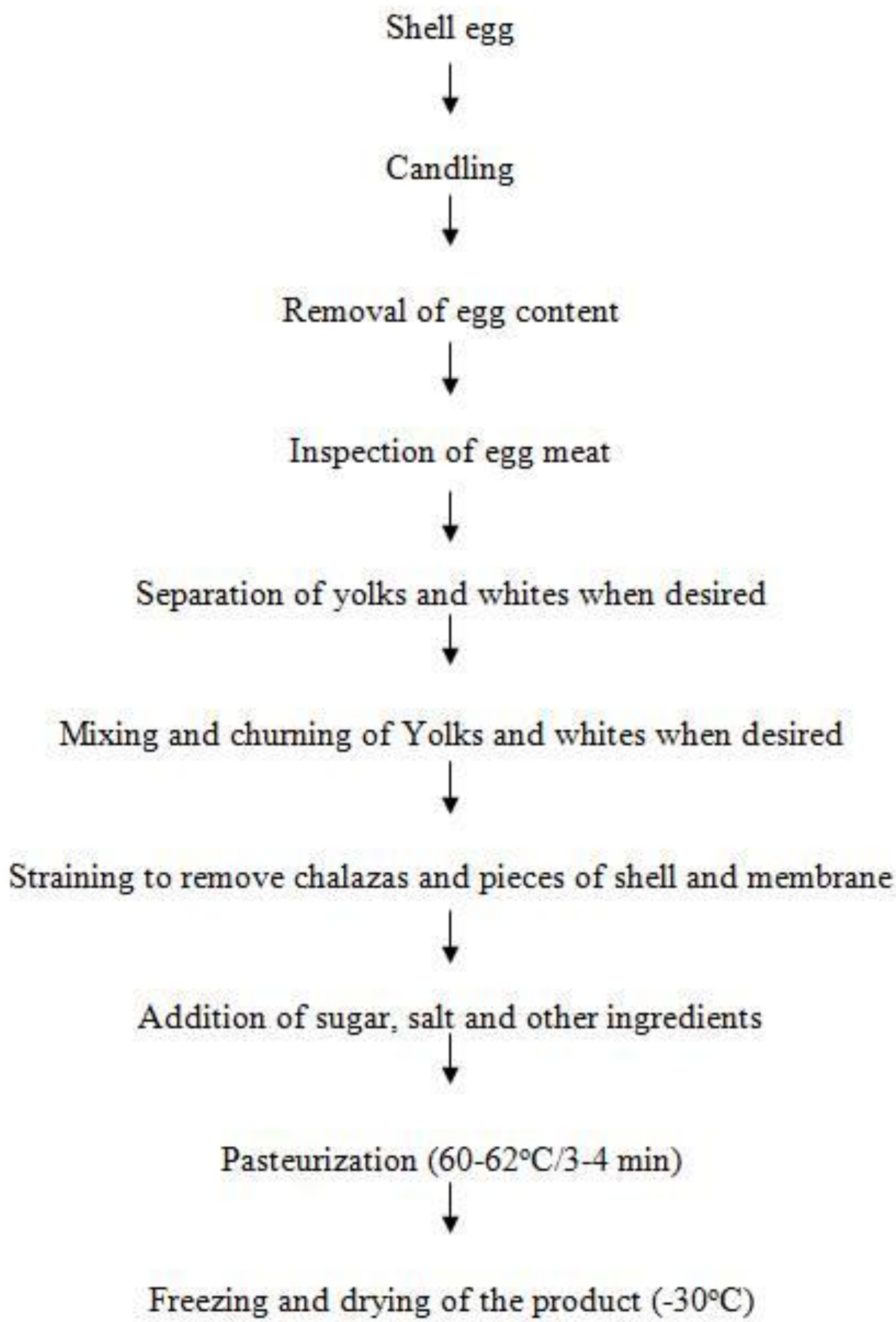

Fig. 1 Process flow chart for frozen eggs

Eggs are frozen to preserve them for use in food manufacturing. Before freezing, Egg yolks, whites, and other yolk-and-white mixes can all be frozen after the egg's inside has been separated from the shell.

Egg receiving, washing, and drying facilities are frequently coupled with freezing units. The eggs are next shattered, either by hand or with the aid of machines, to remove the egg content. The broken eggs are not used since they can taint the finished product. The entire or divided eggs are combined for consistency and filtered to eliminate membranes, chalazae, or shell fragments. In order to freeze the prepared egg contents, they are pasteurised at 60 to 620 C for 3 to 4 minutes. In general, freezing is done in a precise freezer room with air circulating at -300 C. Freezing could take 48 to 72 hours.

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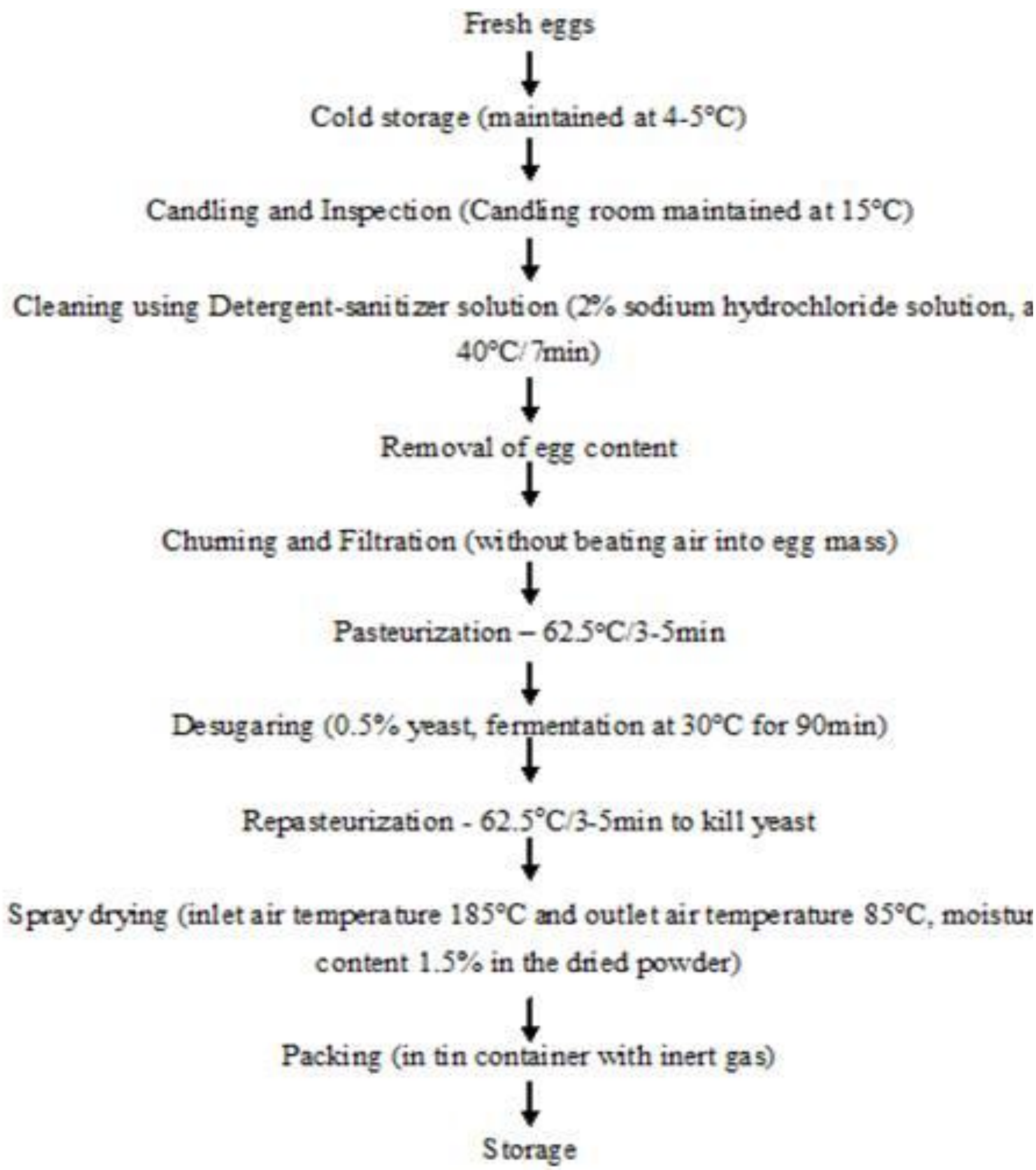

Fig.2. Process flow gram for spray dried whole egg

The whites, yolks, and whole eggs can be dried using a variety of techniques, including freeze drying, foam drying, tray drying, and spray drying. A reaction between egg protein and traces of glucose and galactose in egg white results in maillard browning. This makes the dried egg white discoloured. By eliminating glucose by yeast fermentation or the use of commercial enzymes, browning can be avoided. Desugaring is the process of doing this before drying all of the egg white.

8.11.5. Functional Properties of Egg Content

As a food ingredient, eggs offer a variety of advantageous qualities. Coagulation, emulsification, and foam production are the functional qualities obtained from egg contents.

8.11.6. Coagulation

Heating causes the egg protein to coagulate, which is accompanied by moisture binding and an increase in viscosity. Egg protein eventually assembles into a three-dimensional gel network after denaturing during heating. In various food formulations, including custards, cakes, pie fillings, cream puddings, and others, eggs can therefore be employed as a thickening agent. Salt content, pH, other additives, and heating time all have an impact on the coagulation temperature. Egg yolk coagulates at 65-700 C, while egg white does so at 62-650 C.

Protein that has been heated to coagulation aids in holding the product they are utilised in its shape. As a result, cutlets, chops, etc. use eggs as a binding agent.

8.11.7. Emulsification

The phospholipids, or lecithin and certain proteins, in eggs work wonders as an emulsifier. Egg yolk serves as an emulsifier in mayonnaise to keep oil suspended in vinegar.

8.11.8. Foaming

When eggs are pounded, elastic films are created that can hold air. A good foaming agent is egg and egg-derived compounds. They are relatively stable for cooking and produce a lot of foam. Thus, trapped air expands during baking to produce a product that is fluffy and spongy. As a result, eggs are frequently employed as a leavening agent in baked goods like muffins and cakes.

8.12. Quality checks and storage of egg

Soon after they are laid, eggs begin to degrade, just like any other food product. Therefore, it is crucial to inspect the egg's quality before eating it. Once broken, a good egg should have the following characteristics.

1. Yolk is firm and protrudes from the centre of the white
2. A distinct ring of egg white surrounds the yolk, and the thick white maintains its shape.
3. There are no blood stains.
4. No offensive odour

8.12.1. Changes occur in egg during storage

1. Due to moisture loss, the size of the air cell has increased.
2. A rise in pH brought on by carbon dioxide escaping. pH rises to 9.7 from 7.6
3. As the proportion of thin white rises, egg white loses its form and is more likely to flow.
4. Water moves from the white to the yolk, increasing the fluid content of the yolk.

8.12.2. Indicators to Determine Spoilage in Eggs

1. White index:

   White index = Height of thickest egg white portion/Egg diameter

   Range: 0.08 - 0.1
2. Yolk Index

   Yolk index = Height of Yolk/Yolk width

   Range: 0.35 - 0.45
3. Houghs Unit (HU)

   Commonly used index to check the egg quality

   HU = Height of thick white/weight of Egg

   For good quality egg HU is 72 and above and HU about 30 to 60 indicates poor quality.
4. Air cell size should be 2-3cm

8.12.3. Preservation of the Shell Eggs

Eggs can be preserved by 4 different methods

a Wet immersion method

Use only infertile, fresh, high-quality eggs with this technique.

b Lime sealing method

This approach makes use of a saturated limewater solution. During the 14–16 hours that eggs are submerged in lime water, CO_2 from the egg is released and combines with the lime to generate calcium carbonate, which deposits and plugs shell pores. It is then taken out and kept at room temperature. Such eggs can be kept at room temperature for three to four weeks.

C Water glass method

Sodium silicate 10% solution is referred to as water glass. Before adding the specified amount of sodium silicate, the water in this procedure needs to be brought to a boil and then quickly cooled to between 24 and 260 C to eliminate any dissolved CO_2. After being maintained for one night, eggs are removed and kept at room temperature.

Dry methods

Oiling

By using an appropriate oil to seal the shell pores and stop the evaporation of water, CO_2, and other elements, this method preserves the quality of eggs. You can oil using the dip method or the spray approach. Oiled eggs can be kept at room temperature for up to three weeks.

d. ***Gaseous atmosphere***

Eggs' shelf life was found to be improved with modified environment packing. Maintaining a higher CO_2 pressure around the eggs prevents CO_2 loss from the egg, enhancing the quality of the egg.

e. **Thermization or heat treatment methods**

This technique can be used to retain fertile, fresh eggs. By placing eggs in hot water for 3 to 5 minutes while stirring the water frequently, eggs can be thermostabilized. By causing the albumin to coagulate very closely to the shell, this heat treatment stops CO_2 loss. Thermized eggs can be kept for three to four weeks at room temperature.

f. Refrigeration or freezing:

At -1.0C and 85–90% relative humidity, eggs can be kept fresh for up to 5–6 months. A temperature of -12.80 C and a relative humidity of 60–70% are sufficient for storage for up to three to four weeks.

8.13. By products of Meat and meat products:

8.13.1. Sources of Bone Meal:

- Bone meal is made up of bone fragments that are less than 2 mm.
- Sterilised bone meal is an excellent phosphate supplement in animal feed.
- Animals lacking enough phosphorus in their food and forage develop osteophagia, osteoporosis, rickets, etc.
- Gathering desert bones and turning them into bone meal is a financially sound idea.
- Additionally, it is crucial from a sanitary perspective.
- It can give employment to extremely underprivileged and illiterate persons with limited resources.
- The livestock will always get better as a result.
- It should be mentioned that such bones must be sterilised.
- The yield of bone meal is 1:3, or 1/3 of the production of raw bones.

- The ratio of calcium to phosphorus in bone meal, which is ideal to be 1:2, determines the quality of the product.

- *The average composition of bone meal is*
  - Calcium : 30.5%
  - Phosphorus : 15.5%

- Protein : 7.0%
- Fat : 1.0%

- The remaining blood, fat, meat, and dirt are boiled off the bones under pressure before they are drained.
- • The bones will be sterile and hardly dried.
- • After that, the bones are ground in a disintegrator.

8.13.2. Bone meal applications

• Used as a phosphate fertiliser or as a mineral supplement in stock feeding.

8.14. Sources of Gelatine:

•Glue and Gelatin The most lucrative commercial use of bones is for the production of gelatin. Gelatin is a derivative albuminoid protein with usage in both the edible and inedible (techmeal) realms. Fresh bones acquired from animals butchered under rigorous hygiene guidelines are used to make edible gelatin. Chemically speaking, gelatin and glue are identical. But glue is a subpar gelatin with a relatively dark colour that is primarily used for inedible purposes.

Pure gelatin is a clear, amorphous substance free of any flavours, colours, and aromas. When dried, it becomes brittle, softens when heated, and decomposes with a burnt-hair odour. It absorbs five to ten times its weight in cold water and dissolves at a temperature of thirty degrees Celsius. Gelatin is used to make capsules, bind tables, and lengthen plasma during blood transfusions in addition to being an edible foaming agent in ice cream, jellies, and soft chocolates. It is utilised in the textile and leather industries, photography, etc. on a commercial level as a sizing agent. The adhesive used in plywood, furniture, sand paper, gummed tape, etc. is glue.

8.15. BLOOD Meal

Utilization of Bone, Blood, Horn, Hoof, Wool and Hair Blood weighs about 4-5 per cent of the live weight of the animal. Efficient collection and processing of blood will ensure a profitable return. Blood can be used as human food, as stock feed and also for industrial purpose.

8.15.1. **Blood .**

Meal Whole blood and plasma are used as an ingredient in meat products and pet foods. Blood meal constitutes about 85 per cent of protein. It is a richest source of amino acids lysine, tryptophan and methionine. Blood is often treated in different ways at slaughterhouse. Either, it is discharged into sewage system or renpd together with other slaughter offals and dried for animal feed and technical usage. Blood meal is dark brown, dry (5-8 per cent moisture) granular product produced by drying whole blood. The yield of blood meal ftom whole blood is approximately 20 per cent. Blood meal is used as feed (80 per cent protein) and fertilizer (12 per cent nitrogen, 0.22 per cent phospl~orus and trace elements). It is usually mixed with super phosphate to make a compound fertilizer. Spray dried blood can also be used as an adhesive in asphalt emulsions, insecticides and in ceramics. Blood meal cannot be stored more than one month but its shelf life can be enhanced if lime (CaO) is added to it. Blood meal may be used in calf starter rations, swine and poultry feeds. It is less digestible than meat meal.

Composition

Protein 75 - 83%

Moisture 8 - 12%

Fat 1.2 - 1.6%

Ash 3.8 - 5.6%

sugar 0.4%

Nitrogen Free Extract 2.6%

8.15.2. Preparation of Blood Meal

(Laboratory Method) Blood should be collected carefully with minimum contamination. Preferably blood should be processed on the same day. Small quantity of lime (0.5 - 1 per cent) may be added for storage in a closed container to avoid putrefaction.

After collection, the blood is cooked in an open vessel/pan with continuous Plant stirring to avoid charring. If lime is not added during collection, it should be added during cooking. Lime also helps to preserve the blood meal. Cooking is continued till the blood coagulates totally and excess water gets separated. Cooking serves two purposes: Sterilization (destroying the microbes present) Dehydration (reduction in moisture) The cooked coagulum is strained through a straining cloth and the excess moisture is squeezed out by pressing. The coagulated mass is transformed onto drying tray drying pan and the lumps are broken and spread uniformly on a tray or on a cemented floor, Drying can be carried out either by sun drying or by heating in a hot air oven at 60°C. In tropical countries like India sun drying is more economical, The blood coagulum is dried for 2 - 3 days if it is dried under sun or 8 - 12 hours, if it is dried in a hot air oven or dryer. Then the dried blood is ground and packed in polyethylene bags.

8.15.3. Uses of Blood in Various Industries

Uses of animal blood in various industries are tabulated below.

Table 5.1: Uaes of Animal Blood in Various Industries

Food.	Emulsifier, stabilizer, clarifier, colour additive, nutritional component
Feed	Lysine supplement, vitamin stabilizer, milk substitute, nutritional component
Fertilizer	Seed coating, soil pH stabilizer, mineral component.
Laboratory	Tissue culture media, haemin, blood agar, peptone, glycerophosphates, albumin, globulin, sphingomyelin, catalase
Medicine	Asglutinin test, immunoglobulin fractionation techniques, blood clotting factors, sutures, fibrinogen, fibrinolysin, fibrin products, serotonin, plasrninogen, plasma extenders.
Industry	Adhesive, resin extender, finishes for leather and textiles, insecticide spray adjuvant, egg albumin substitute, foam fire extinguisher, porous concrete, ceramic and plastic manufacturer, plastic and cosmetic base formulations.

8.16. Sources of casing

Quality casing prepared from sheep, goat and pig intestines is essentially composed of submucosal layer/submucosa only. Other three layers mucosa, muscularis and serosa are removed during processing. Whereas casing prepared hm cattle intestines has submucosa and some muscular coats. Submucosa~submucous layer is of grayish, yellow or red colour and composed of dense connective tissue network. The casings are made from submucous coat only because of its fine structure, flexibility, elasticity, strength and ability to shrink and extend without cracking

8.16.1. Principle

Preparation of casings using intestines of sleep and goat, by scraping unwanted layers i.e., mucous layer, muscular layer and serous layer.

Requirements

Equipment and raw materials for processing of casings are listed below:

1) Scrapers - Made of hard wood and shaped like a knife. - Spoon scrapers made of bone or plastic.

2) Gut cleaning unit - Comprises of three vessels made of casks on a sliming table.

3) Sliming table - Made of steel with central drain. The table should have a slight slope towards, the central drain. Used for keeping the casks and for desliming the intestines. Cask for water. Cask for chilled water. Cask for waim/hot water. Sliming platform. Central drain point for collection of slime and waste. Tub for collection sliine.

4) Skeining basket: used to skein the casings uniformly into hanks.

5) Abundant supply of cold clean water.

6) Fresh clean salt.

7) Raw intestine

8.16.2. **Procedure**

1) **Removal:** Remove the whole intestine while evisceration without any damage. Ligate the intestines at both the open ends and prevent the running out of the contents.

2) **Pulling and Running:** Separate the intestines froin its mesenteric attachments and the fat by applying gentle force. Divide the intestines into different parts requiring different treatments. Running is also the same term, but here the operator will hold a knife in one hand and pull the intestines with the other hand. Generally, running is being done in case of cattle intestines. 'l'he sharp edge of the knife scrapes of the fat and sometimes the relatively strong attachments of the mesentery.

3**) Chilling:** After separation, chill the intestines to a temperature of 3 0-1 j°C to prevent microbial growth and fermentation.

4) **Stripping:** Strip the intestinal content by pressing and passing between the fingers with gentle pressure and flush the intestines with running cold water as the water carries away the intestinal contents as they are removed.

5**) Defatting:** Remove and clean all the specks of visible fat from the intestinal surface.

6). Fermenting:

Immerse the defatted intestines in warm water at 25OC. 'This is performed to facilitate the loosening of different layers by enzymatic and bacterial action. The temperature is very critical as high temperature results in blown casings due to over fermentation resulting in easy tearing and objectionable odour.

7) Turning: Turning the casings inside out for effective sliming. This is done in cattle intestines as they are having hard muscular tissue.

8) Sliming: Removal of unwanted layer i.e., mucosa, serosa and muscular layers is known as sliming. To facilitate easy and efficient sliming, immerse the fermented intestines into cold water containing 0.2% poly phosphate and 1% sodium cldoride. Gently scrap the intestine using a sliming stick, bone or a plastic knife till white or almost white or transparent casings are obtained. Wash the slimed casings thoroughly with water.

9) Inspection: Inspect the slimed casings for any abnormalities and abnormal conditions.

10) Measuring and grading: Grade the casings by measuring the diameter of the casings eidler by inflating air or water or by measuring flat diameter. The diameter is measured using a calibration gauge divided into compartments of different calibers ranging for 14 mm to 24 mm. The length is measured by using a curved structure made of wood and makes them into rings and hanks. Usually, one turn of a ring is adjusted to give 1 ' (30 cm) of length. Aring measures 75' or 22.9 m and 4 rings makes a hank (300 feet).

11) Salting and curing: lmnlerse the measured casings in saturated salt solution for about 24 to 48 hours. Then remove fiom brine and apply fine salt liberally and rub on the surface of the hank. Keep the salted stock in wooden bins with perforated bottom (Which permits easy drainage of brine after selling of casings) curing is complete when brine ceases to ooze. It takes 2-3 days time. Shake the casings to remove excess salt.

12) Packing: Pack in wooden containers or metal crates lined with polyethylene or cotton to prevent rusting.

8.16.3. RECAUTIONS DURING ALL OPERATIONS.

Greatest care should be taken to ensure that the intestines are not ruptured. Casings should not be prepared in direct sunlight. Preparation of Casing Casings should never be washed in rivers or streams.

8.17. CONCLUSION

Meat processing entails a variety of procedures including fermentation, canning, curing, smoking, emulsion preparation, restructuring, and enrobing. Each procedure yields a particular kind of product and calls for various starting materials, chemicals, cooking techniques, and packaging. Meat proteins are solubilized during emulsion formation and cover the fat molecule particles. So, stop fat and water from evaporating when cooking. Small meat fragments or meat trimmings are bound together by proteins taken from the flesh in reformed goods. Bacterial cultures are infused into the meat to prepare fermented meat products. These goods are more shelf-stable and have a lower pH. Products are heated to a high temperature during canning in order to destroy microorganisms that cause deterioration. By coating meat products with edible coating materials during the anarobic process, product characteristics are further enhanced.

The products in meat products with intermediate moisture levels have longer shelf lives thanks to lower water activity. As a result, by properly processing meat, we can guarantee effective utilisation of low-value meat and byproducts and can provide consumers a wide variety of delectable meat products. In addition to helping unemployed youth find employment, meat processing also helps to combat undernutrition in our nation by offering high-quality proteins at reasonable prices.

When preparing meat, the use of various non-meat components, sometimes known as additives, is crucial. These give the product variety and convenience. Combinations of components are typically utilised because one ingredient cannot give a product all the necessary qualities. Each component other than meat should be chosen for an essential function.

As a binder or extender in meat products, soya proteins, milk proteins, cereal/pulse flours, starches, eggs, vegetables, colloids, gums, and blood proteins are used. To improve colour, flavour, and shelf life of the food, several curing agents such as salt, sugar, sodium nitrite and nitrate, phosphate, monosodium glutamate, etc. are utilised. Additional flavour enhancers, acidulants, sweeteners, and colouring agents are also added to foods as additives. Use of these components shouldn't go above recommended amounts. Non-meat ingredients are also important factors in deciding the product's price.

REFERENCES

- Ranken, M.D. (200 1). Handbook of Meat Products Technology. Blackwell Science Ltd.
- Romans, J.R., Costello, W.J., Carlson, C.W., Greaser, M.L. and Jones, K.W. The Meat We Eat, 13Ih edition. Inter-state Publishers Inc., Danville, Illinois.
- Avantina Sharma, 2006. Food science and technology, IBDC publications, Lucknow
- Vijaya Khader, 2001, Food science and technology, ICAR, New delhi.
- Ranken, M.D. (2001). Handbook of Meat Products Technology. Blackwell Science Barbut, Shai. Poultry Products Processing. CRC Press, Boca Raton, Florida.
- Pearson, A.M. and Gillet, T.A. (1999). Processed Meats, 3"edition, An Aspen Publication, inc., Gaithersburg, Maryland.

UNIT IX: ADDITIVES AND PRESERVATIVES

9.0. DEFINITION OF FOOD ADDITIVES

Since ancient times, food additives have been utilised to improve the quality of food products. More than 10,000 years ago, foods were preserved with the help of smoke, alcohol, vinegar, and spices. Additionally to advancements in food chemistryIn the early 1900s, the usage of food additives greatly grew for food preservation. The demand for novel, delectable, practical, and nourishing foods was rising. As a result, by the early 1960s, several developed nations were using more than 2500 distinct chemicals in food.

Various individuals used to understand food additives in various ways. A material or combination of substances, other than a fundamental food, that is present in a food as a result of any part of production is generally acknowledged as a food additive.Food additives are compounds that are consciously introduced for particular purposes. Currently, a relatively significant number of additives are utilised in food. Although they can be divided into a few groups according to their functional characteristics-Preservatives, antioxidants, acidulants, neutralizers, and buffers, colouring agents, flavouring agents, and sweeteners are a few examples of possible additives ,nutritional additives, and other additives.

Although widely recognised, the use of food additives is not without debate. Concerns have been raised about the potential short- and long-term dangers of ingesting these drugs.Concerns have been raised about the potential short- and long-term dangers of ingesting these drugs. The maximum allowable limits (Acceptable Daily Intake, ADI) of additives have been established based on the scientific data currently available on the toxicological status of each additive and the likely quantity of that ingredient consumed through a particular meal. As you will see in later courses, every nation has established its own food laws. For example, India's Prevention of Food Adulteration Act (PFA) and Rules, 1954, outlines the additives that are allowed in various foods as well as the highest authorised levels. Additionally, you will learn that our food standards are being synchronised with other countries' food standards.As a result, it is anticipated that the current list of authorised chemicals under PFA will grow soon. Keeping these things in mind, various significant and useful food additives are covered in this unit, even though some of them might not currently be covered by PFA. Vitamins and minerals, which are nutritious supplements, have already been discussed in the previous unit; they will not be covered in this one.

9.1. ACIDULANTS

Many of the functional qualities that acidulants bring to the table improve the quality of food. Organic acids are utilised as the majority of food acidulants. Acetic, ascorbic, citric, lactic, malic, and tartaric acids are among the organic acids and salts that are frequently employed in meals. Additionally, phosphoric acid and other inorganic acids are frequently utilised in cola-style drinks. Pants commonly include organic acids like citric, malic, and tartaric acids. Vitamin C, or ascorbic acid, also comes from plants. As the name suggests, lactic acid comes from milk. Acetic and ascorbic acids aren't specifically described here because several parts of them have already been covered elsewhere.

The most common organic acid is probably citric acid. It is a tricarboxylic acid that can be found in large quantities in citrus and other fruits. Although citrus fruits were once used to make it, most commercial citric acid is now made through fermentation. White crystalline powder, or citric acid, is readily soluble in water. The monohydrate of citric acid is offered for sale commercially. Its nature is hygroscopic. Citric acid is therefore not a great choice for use in dry food compositions.

Malic acid is a dicarboxylic acid called 2-hydroxybutanoic acid. It is the primary acid found in mangoes and apples. It is a white, crystalline powder that dissolves quickly in water. Commercially, synthetic malic acid is offered. Malic acid is favoured for use in dry food compositions since it is non hygroscopic.

Another dicarboxylic acid is tartaric acid. It is the main acid found in tamarind and grapes. Additionally, it is a water-soluble white crystalline solid. Typically, it is isolated from the argol sediment that results from the fermentation of grapes.

Baking powder and fizzy 'health salts' both use tartaric acid.

Common uses for acidulants

The right acid choice will depend on the desired acid property or qualities and a mix of those traits, as well as the acid's price. Below are some of the general functions.

• Flavouring substances They hide unpleasant tastes while enhancing some flavours and sensations.

• Buffering action: Organic acid salts, particularly sodium salts, regulate the pH of food at different stages of processing as well as in the final product.

• Preservation: By lowering pH, you can avoid food spoiling and food poisoning by stopping the growth of microbes and the germination of spores.

• Sequestering: Bind metal ions and improve antioxidant performance.

• Viscosity modifiers: Similar to those found in dough, they alter the shape and texture of baked goods.

• Meat curing agent: Enhances colour, flavour, and preservation action when combined with other curing ingredients.

The majority of food acidulants are legal under PFA with some limitations.

9.2. CHELATING AGENTS,

Chelating agents are food additives that extend the shelf life of baked goods by preventing oxidation. Metals are trapped by them, preventing them from contributing to colour or flavour deterioration. Chelating agents are organic compounds having a ring-like centre that, when combined with a mineral ion, form at least two bonds, or what is known as chelates, which are complicated structures.

Examples of these are:

- EDTA, or ethylenediaminetetraacetic acid
- Polyphosphates
- such as tartaric or citric organic acids

Function

The Greek word "chele," which signifies a crab's claw, is where the word "chelate" comes from. Chelating agents must have two specific qualities in order to function:

1. Two distinct binding locations for the metal it chelates.
2. Ability to work in concert with the metal ion to form a ring.

Metals can interact with food system components or serve as cofactors for enzyme activity. Examples include calcium, zinc, iron, copper, and many others. Chelating chemicals can postpone or slow down these processes by binding to metals, protecting the functional and sensory qualities of food products. Some chelating substances can also work well as antioxidants.For instance, the most well-known chelating agent is EDTA. Most commonly, calcium disodium EDTA, disodium EDTA, tetrasodium EDTA, and other EDTA salts are generated.Several typical varieties in baking:

1. The most well-known chelating agent, ethylenediamine (EDTA), is a multi-dentate molecule because it may create two distinct bonds.

2. Disodium pyrophosphate is produced when phosphoric acid and sodium carbonate interact chemically, resulting in sodium phosphate, which then needs to be heated further to produce disodium pyrophosphate. Disodium pyrophosphate's main use in baking is as a source of acid that can be used to combine with baking soda to produce leavening. Due to the creation of carbon dioxide gas during fermentation, which creates air pockets within the crumb and the evaporation of alcohol, leavening promotes rise in the product.The ability of the baked good to

retain more water, which results in enhanced moisture and extended shelf life, is a second function.

3. The chelating property of phosphoric acid prevents oxidation brought on by metal ions.

4. Citric acid: Has the ability to maintain scent and decrease the rate of discolouration. fruit fillings in pastries and other baked goods use it as a preservative.

Natural chelating substances

The quest for substitute clean-label compounds, has been motivated by the synthetic origin of EDTA and its non-biodegradable nature such as:

- Chlorella
- Glycine
- Food-Grade Activated Charcoal

None of these, however, has been utilised to successfully replace EDTA.

9.3. ANTIMICROBIAL AGENTS

Since many years ago, it has been recognised that bacteria can create antimicrobial compounds (antibiotics). However, only recently have some of these chemicals been approved for use in food. In some dishes, nisin and natamycin are authorised.Steptrococcus lactis, now known as lactococcus lactis, is a polypeptide producer. The pH of the medium affects the compound's solubility. In neutral pH, it is practically insoluble, and it is more soluble in acidic pH.

Only gram-positive bacteria, such as lactic acid bacteria, streptococci, bacilli, and clostridia are affected by the restricted spectrum of nisin. Gram-negative bacteria, yeasts, and molds are typically not inhibited by it. Nisin has a pH-dependent antibacterial effect that is stronger as the pH drops. It works at extremely low doses of 0.04 to 2.0 ppm.

Under PFA, nisin is permitted in canned rasagolla and packaged coconut water.Streptomyces natalensis is the bacteria that makes natamycin. The substance has a sizable lactone ring that is replaced by one or more sugar residues. Ineffective against bacteria, viruses, and actinomyces, natamycin is largely effective against yeast and mould. Additionally, natamycin works well at very low concentrations of 5–10 ppm. Hard cheese surfaces may now be treated with natamycin.

9. 4. STABILIZERS AND THICKENERS

Consumers expect specific levels of quality and gastronomic satisfaction from processed meals. Stabilisers, thickeners, and gelling agents, which give food a consistent texture, flavour, and mouth feel, help to achieve this in part.

a. Definition

Stabilisers, thickeners, and gelling agents are permitted direct food additives that are extracted mostly from natural sources and added to foods to give structure, viscosity, stability, and other properties including maintaining current colour.

b. Labelling, Names, and Functions

Although thickeners, stabilisers, and gelling agents are each given their own classification, their functions are similar. They produce rigidity, stabilise emulsions, or create gels when they are dissolved or added to food.

Thickeners are chosen for their versatility in a range of chemical and physical circumstances. They can be flavourless powders or gums.The pH, frozen state, clarity, and taste of the thickener can all be influenced by many factors. The most often used commercial thickeners in soups, sauces, and puddings include starches, pectin, and gums.

Stabilisers are compounds that assist meals stay in an emulsion and preserve their physical properties, increasing stability and thickness. Stabilisers are necessary for ingredients like oil and water that don't often combine. Stabilisers are necessary for many low-fat foods. Ice cream, margarine, dairy products, salad dressings, and mayonnaise frequently contain lecithin, agar-agar, carrageenan, and pectin.

In jellies, jams, sweets, yoghurt, and candies, gelling chemicals also serve as stabilisers and thickeners to offer thickening without rigidity. Common gelling agents include gums, starches, pectin, agar-agar, and gelatin.

With the inclusion of well-known starches, cereals, egg yolks, yoghurt, gelatin, mustard, and vegetable purees, home cooking produces the same structural alterations.

To facilitate swallowing and lower the danger of aspiration, thickening agents are also used to treat medical problems including dysphagia.

Food labels provide a classification, such as "pectin (gelling agent)," to help consumers understand the purpose of the food additive. The majority of direct additions are listed on food ingredient labels.Most polysaccharides and protein-based thickeners, stabilisers, and gelling agents come from sources like:

Polysaccharides

- arrowroot, cornflour, potato starch, sago, and tapioca starches
- Guar gum, extracted from guar beans, xanthan gum, derived from microbial fermentation, and locust bean gum, derived from carob trees, are examples of vegetable gums.

  - Pectin (from citrus or apples)
  - Gelatin (made from animal collagen), egg whites, collagen, and whey
  - Other sugars include agar (made from algae) and carrageenan (made from seaweeds and used to stop dairy products including ice cream from separating).
  - Sodium pyrophosphate, a chemical found in many everyday goods including canned salmon and instant pudding.
  - Lecithin (found in maize, beans and egg yolk)
  - (Stabilisers that are naturally present in many seed oils: mono- and diglycerides)
  - In addition to being predominantly natural (carboxymethyl cellulose, methyl cellulose), sources can also be manufactured (arrowroot, gelatin, starches).

Oversight

- Before usage, thickeners, stabilisers, and gelling agents must have Food and Drug Administration approval. Food additives must meet tight criteria and strict standards in order to be approved, and there must be a legitimate reason for their use.
- Depending on the additive and the meal it is used in, there are different maximum usage levels.
- For instance, stabilisers cannot make up more than 0.5 percent of the final weight of frozen dairy desserts, fruit and water ices, confections, and icing. The maximum allowed amount of emulsifier, adjuvant flavouring, stabiliser, or thickening in baked goods is 0.5 percent by weight.

Safety

Food additives are subject to more scrutiny, regulation, and oversight today than ever before. To reduce potential negative impacts on human health, all new food additives go through extensive testing and safety evaluation. Large amounts, however, may cause adverse reactions and nutrient-drug interactions. For instance, eating more than 15 grammes of xanthan gum may make you queasy, bloated, and flatulent.It is possible for foods and medicines to interact. Carrageenan and pectin both have the potential to have negative side effects on those taking anticoagulants and antihypertensive medications.

9.5. FAT REPLACERS

- Nonfat ingredients called "fat replacers" mimic the effects of fat in diet. A material that tastes and looks like natural fat but contains less calories would make the perfect fat substitute because it poses no health dangers. Foods including cheeses, sour cream, yoghurt, margarine, salad dressing, sauces, and gravies all contain fat substitutes.
- There are three main categories for fat substitutes:

- Carbohydrate-based. These are produced using starchy ingredients including corn, grains, and cereals. Today's fat substitutes are typically manufactured from carbohydrates. Dextrins, gums, cellulose, gelatin, and modified dietary fibres are a few examples.
- Protein-based. These are produced by altering protein using egg whites or milk whey. Whey protein, microparticulated egg white, and milk protein (like Simplesse) are other examples.Fat-based. In place of triglycerides, they are created in vegetable oils. Caprenin, salatrim (found in Benefat), and olestra (found in Olean) are a few examples.
- It may be difficult for consumers to detect fat replacers in the meals they purchase because their brand names aren't always featured on the ingredient label.If you decide to utilise fat substitutes, consider the following:
- Protein- and carbohydrate-based fat substitutes don't harm health, according to recent research.
- Olestrá, a noncaloric fat replacement, prevents the body from absorbing fat-soluble nutrients such carotenoids and the fat-soluble vitamins (A, E, D, and K). Plants include pigments called carotenoids, which act as antioxidants in your body. Carotenes and lycopene (found in tomatoes) are two examples.Cramping, bloating, and loose stools are olestra's side effects.
- Compared to foods that include fat, those with fat substitutes may have fewer calories. However, some individuals could have a tendency to consume more of the replacer-containing meal, making up for the lost calories.
- More study is required on fat substitutes. Speak to a certified nutritionist about adding fat substitutes to your diet.

9.6. FIRMING TEXTURIZERS

The addition of firming agents strengthens the supporting tissue and prevents collapse during processing by precipitating residual pectin. Pectin is a naturally occurring substance found in fruits and vegetables that forms a stiff gel around the fibrous tissues of the fruit to prevent it from collapsing. When calcium salts are added, calcium pectate gel forms, supporting the tissues and providing protection from softening during processing. In the form of a tablet containing both sodium and calcium chloride, the calcium salt is occasionally added to the canned vegetable.

To keep them from softening and disintegrating during processing, canned vegetables, canned apples, frozen apples, and tomatoes are occasionally given a calcium chloride, calcium citrate, monocalcium dihydrogen phosphate, calcium lactate, or calcium sulphate treatment.The recommended level of use for these calcium salts, measured as calcium in the finished food product, is 0.02%. Calcium chloride and calcium citrate are used in canned potatoes at a level of 0.5% (calculated as calcium).

Pickles and relishes use acidic aluminium salts such sodium aluminium sulphate, potassium aluminium sulphate, ammonium aluminium sulphate, and aluminium sulphate as firming agents. Aluminium sulphate, a more contemporary firming agent, is used in canned crab, lobster, salmon, shrimp, and tuna.

Below, significant firming agents are addressed.

9.6.1.Chlorideof calcium

Calcium chloride is used as a firming agent in canned vegetables, the process of turning soy bean curds into tofu, and the creation of a caviar alternative from fruit or vegetable liquids.It works with gelling chemicals to reinforce food structure or helps keep fruits and vegetables solid. The firming agent in cheddar and cottage cheese is calcium chloride.

In sensitive individuals, calcium chloride may cause stomach irritation.

9.6.2. Calcium phosphates

Hydrated lime and phosphoric acid combine to produce calcium phosphates under carefully controlled circumstances that maximise the production of the desired product.

In order to strengthen the firmness of canned vegetables like carrots and tomatoes and to improve the structure of low-gluten flours, monocalcium phosphate is employed as a calcium source.

9.6.3. Konjac

- The tuber of the Amorphophallus konjac plant is where konjac gum and konjac glucomannan, sometimes referred to as konjac flour, yam flour, konnyaku glucomannan, and glucomannan gum, are extracted.
- Konjac gum, kappa, and carrageenan are used in 0.6% of table dessert gels and aspics to produce solid, cohesive textures. In coarse-ground meat and sausage imitations, the thermally stable glucomannan gel is used as a water binder and texture enhancer.

- Aspics, surimi, frozen sweets, sauces, and batters are examples of typical items.

9.6.4. Sulphate of calcium

- Plaster of Paris is another name for the naturally occurring mineral calcium sulphate.
- In order to add the calcium and sulphate ions that are found in naturally hard water, calcium sulphate is used to prepare water for brewing.
- It is also utilised to supply calcium ions to natural cell-wall pectin in canned fruit and vegetables, which reacts to maintain the pieces' firmness. It increases cell strength and bubble stability during baking.

9.7. APPEARANCE CONTROL AND CLARIFYING AGENTS

- Clarifying agents are those who bring about clarification. Clarifying agents are used to get rid of some solids that give liquids a foggy appearance.
- beer, carbonated beverages, etc.
- Clarifying chemicals are what give these drinks their dazzling clarity.
- Fruits contain pectin, a complex carbohydrate. It creates a fibrillar network in three dimensions. When cereal malt is used as a foundation, pectin, fibrous tissue, and certain hemicelluloses must be removed since they give beverages a muddy look. Clarifying chemicals are employed to create clarity.

Natural Agglutinants:

1. Activated carbon: Some of the suspended particles can be removed through adsorption.

2. Gelatin, which is made from animal collagen a protein that is positively charged However, because it discolours food, tannins are added as well.For instance, apple juice with cashews.The juice's colloids coagulate to form a flocculant precipitate, which settles. It is brought on by the electrostatic attraction between the negatively charged pectin and positively charged gelatin colloids. Between the phenolic group in juice and the peptide group in gelatin, hydrogen bonds are created.

3. Albumin: made from egg whites and juice cooked to 910 c. Albumin (2%)

4. Casein: A 2% casein solution is added, and after 24 hours, the casein precipitates from the juice's acids.

5. Tannin and Gelatin Combination: Tannin is used to lessen the bleaching effect of gelatin.Then, clear juice is separated using a syphon.

Clarification is achieved using certain enzymes.

- Filtragol
- Pectinol

Pectins are broken down by pectin methyl esterase, a type of pectin-digesting enzyme. In addition, physical techniques like freezing and heating can be applied.

9.10. FLAVOUR ENHANCERS

- Food flavour and colour both have a significant impact on consumer acceptance, and as a result, are of huge commercial significance. Despite some research suggesting that taste can affect intestinal absorption of glucose and fat metabolism, it appears to have little nutritional value. There are various definitions for flavour. "Sensation produced by a material taken in the mouth, perceived primarily by the senses of taste and smell, as well as by general pain, tactile, and temperature receptors in the mouth," is one definition.

- The topic of food flavours is fairly broad. In a following unit, you will study flavour analysis and sensory experience. You will discover some crucial information on the chemistry and use of food flavourings in this section.In the beginning, spices were employed to improve or alter the flavour of food. A surge in synthetic taste chemicals and their identification in various foods and processed goods occurred along with advancements in synthetic chemistry and analytical methods like gas chromatography and mass spectrometry. Techniques for sensory analysis play a big part in flavour research. One significant discovery was that very sometimes did a single chemical compound account for the distinctive flavour of a dish; instead, the majority of food odours were the result of a mixture of several chemical compounds. Menthol in peppermint, benzaldehyde in bitter almond, citral in lime peel, amyl acetate in ripe bananas, cinnamon, and others are a few examples.
- It became clear that developing a food flavour is a difficult process as a result. However, a wide variety of flavour compositions are now available thanks to a combination of artistic and scientific knowledge. It is a very sizable industry. Three groups make up the classification of food flavourings.
    - Natural flavours and natural flavouring ingredients are flavour mixtures and single ingredients, respectively, that are suitable for human consumption. They are obtained solely through physical means from raw vegetable and occasionally animal materials, either in their natural

state or after processing, for human consumption.
    - Flavouring ingredients that are chemically equivalent to those found in naturally occurring items intended for human consumption, whether processed or not, can be produced synthetically or chemically separated from aromatic source materials.
    - Artificial flavouring ingredients are those in natural goods intended for human consumption that have not been identified, whether they have been processed or not.
- Spice oleoresins and oils, essential oils like citrus oils, fruit aroma concentrates like apple aroma concentrate, etc. are some examples of natural tastes. As was already said, there are a tonne of synthetic flavouring agents.
- Therefore, only those flavouring chemicals that are prohibited by PFA are listed, rather than the approved flavouring substances. In this context, it's crucial to remember that natural or artificial flavours require extremely low concentrations of flavour chemicals—on the order of parts per million or parts per billion—to impart the required flavour perception. Due to their self-limiting nature, maximum allowable limitations are not applicable to them.

9.11. AROMA SUBSTANCES

- Vegetables, herbs, and spices that give aroma and flavour to food are known as aromatics. Use a variety of aromatic combinations when preparing foods from other cuisines.The vegetables, herbs, and spices that chefs utilise as the base of a dish's flavour are referred to as aromatics. For sauces and stir-fry recipes, sauté aromatics in butter or oil at the start of the cooking process. You may also wrap aromatics into a sachet and simmer them in liquid to make broth, stock, or soup. Different cuisines use different aromatic combinations as the foundation for flavour.
- In cuisine, there are three primary categories of fragrant ingredients:
    - Herbs: Both fresh and dried herbs can be used as aromatics. Herbs can be divided into two categories: sensitive herbs, commonly referred to as soft herbs, and hard herbs. Tender herbs, such as cilantro, chives, tarragon, parsley, dill, mint, and basil, have soft stems and leaves. Hard herbs have tougher leaves and hard, woody stems. Popular hard herbs include sage, bay leaves, ginger, galangal, lemongrass, oregano, thyme, and fennel.
    - Spices: Whole and ground spices are common aromatics as well, especially in Asian and Indian cuisine. Chilli peppers, cumin, coriander, cardamom, turmeric, paprika, and other spices have strong aromas.
    - Vegetables: To start off the cooking procedure, sauté some fresh vegetables in butter or cooking oil.Onions, shallots, scallions, celery,

garlic, carrots, leeks, and bell peppers are some common fragrant vegetables. Dice the vegetables for quick preparations, and use large chunks for slow-cooking dishes like stock.

The Use of Aromatics in Cooking

For stews, braises, stir-fries, and soups, aromatics serve as the foundation. Take into account the following fragrant pairings for varied cuisines:

1. The holy trinity of sliced carrots, onions, and celery sautéed in butter or oil is referred to as "mirepoix" in French. Many well-known French and American meals, like boeuf bourguignon and chicken noodle soup, start with mirepoix as their foundation.

2. Sauté carrots, onions, and celery in olive oil to make soffrito, an Italian take on mirepoix

To prepare bolognese, lasagna, and other Italian soups and stews, home cooks utilise soffritto.

3. Cajun: Onions, green bell peppers, and celery are often sautéed in butter or oil to create the fragrant base for many Cajun meals like gumbo and jambalaya.

4. Spanish: A flavorful sauce called sofrito is made in Spain with tomato paste, garlic, bell peppers, cilantro, parsley, and various spices. To intensify the flavours that may be added to meals like paella, empanadas, and stews, this tasty base is slowly simmered in olive oil. In Latin America, there are various regional sofritos; the cuisines of the Dominican Republic, Puerto Rico, and Brazil all offer distinctive varieties.

Depending on the location, cooks may add other aromatics, like dried chilies in Sichuan cuisine.

6. Thai: Shallots, garlic, and chilies form the foundation of Thai cooking. (Coconut milk is a component of curry recipes). Galangal, lemongrass, and kaffir lime leaves are some more ingredients that are frequently used to flavour food.

7. Indian: Curries, meat, and vegetable dishes of Indian cuisine use a variety of spices. Indian cooking typically starts with the heating of spices like cumin, cardamom, turmeric, and cloves in ghee or oil. Along with the aromatics, frequent flavourings include tomatoes, onions, ginger, and yoghurt.

9.12. SUGAR SUBSTITUTES:

9.12.1. SWEETENERS

- One of the essential tastes is sweetness. The massive production of sugar (sucrose) worldwide is a reflection of the value of sweetness. Sucrose is taken for reasons other than sweetness. It also has numerous useful such as a bulking agent, texture altering agent, and preservative.

- Like all other carbohydrates, sucrose is a food that gives the body energy. The development of obesity, disorders that are related to it, as well as dental cavities, have all been linked to sugar throughout time. In addition, diabetes has spread to affect significant portions of the population. As a result, there is a general tendency to consume less energy. This led to the creation of sucrose substitutes.There are two categories of sweeteners to choose from: nutritive and non-nutritive. Carbohydrates or their derivatives—also known as calorie sweeteners—usually make up nutritional sweeteners. A variety of organic ingredients as well as some artificial compounds make up non-nutritive sweeteners.

9.12.2. Healthy Sweeteners

- In a previous unit, you previously learned about the relative sweetness of glucose, glucose syrup, fructose, and high fructose corn syrup. You will learn about a few different healthy sweeteners in this section.
- **Sorbitol:** A six-carbon sugar alcohol known as sorbitol was first discovered in the berries of mountain ash. It is made chemically from glucose for use in industry. At 25 °C, it is quite water soluble (72%). The sweetness of sorbitol is half that of sucrose.
- Sorbitol is used as a sweetener for diabetic meals, sugar-free chocolates, and chewing gum since it has fewer calories than sucrose.
- **Xylitol:** The majority of fruits and berries as well as plant materials that contain the polysaccharide xylan contain xylitol (also known as xylit), a pentiol. Additionally, it is made via microbiological processes. The crystalline compound xylitol has a high water solubility (64 percent at 25 °C). Similar to sucrose in terms of sweetness and calorie content.
- However, unlike glucose or sucrose, xylitol absorbs slowly, therefore it does not raise blood sugar levels. As a result, it is also utilised in foods for diabetics.
- Hydrogenated isomaltulose is another name for isomalt. 6-0-D-glucopyranosyl-Dglusitol and 1-0-D-glucopyranosyl-Dmannitol are mixed in an equimolar ratio. Enzymatic transglucosidation of sucrose to isomaltulose and hydrogenation result in the production of isomalt. Its sweetness is around half that of sucrose.
- When used in food processing under typical conditions, it is stable in both acidic and alkaline media. It doesn't affect blood sugar levels. In candies, gum, soft drinks, and desserts, isomalt is used in place of sugar.

9.12.3. Artificial sweeteners

- The synthesis of saccharin took place in 1879. Due to the shortage of sugar during the two world wars, saccharin's use as a sweetener increased. Despite repeated concerns about its safety, saccharin became a common sweetener for specialised dietary and dietetic items.

- Sodium saccharin, calcium saccharin, and saccharin are all referred to as saccharin collectively. Saccharin is 1,2-benzisothiazol-3 (2H)-one-1, 1-dioxide chemically speaking.
- White crystalline powders, sodium saccharin and saccharin, are soluble in water.
- They have a 500-fold greater sweetness than sucrose. It maintains good stability when food products are being cooked and baked, however it has a little metallic aftertaste. With limitations, it is legal to use as a sweetener in several nations, including India.
- The available toxicological evidence does not definitively link saccharin to any major health risks. Saccharin's Acceptable Daily Intake (ADI) is set by the WHO at 2.5 mg/Kg body weight. However, as more and more study findings mount, safer substitutes for saccharin are certain to appear.
- Cyclamates: Although sodium cyclamate was first synthesised in 1937, it wasn't until 1950 that it was first used as a sweetener. Cyclamic acid, sodium cyclamate, and calcium cyclamate are all referred to as cyclamates. By sulphonation, they are produced from cyclohexylamine. In nature, they are not to be found.
- Cyclamates are easily soluble in water and stable at high temperatures. They can be utilised as a noncalorie sweetener in a number of goods and are approximately 30 times sweeter than sucrose. It may occasionally be used with saccharin.
- Cyclamates raise several safety concerns. Therefore, much like with most other non-nutritive sweeteners, its use is only permitted under certain conditions. Under PFA, cyclamates are not allowed to be used. It has an ADI of 11 mg/Kg of body weight.
- Aspartame: This sweetener was only identified in 1960. It is L-aspartyl-L-phenylalanine's methyl ester. The amino acids phenylalanine and aspartic acid are used to make aspartame. It is a flavourless, white, crystalline powder that is around 150–200 times sweeter than sucrose and just marginally soluble in water.
- Aspartame has 4 Kcal of energy per gramme. Aspartame gives meals a sweetness similar to sugar, but when it is exposed to particular moisture, temperature, and pH levels, it hydrolyzes and loses its sweetness. As a result, despite its widespread use in soft drinks, dairy products, and other items, aspartame is better suited for dry goods or as a tabletop sweetener. The typical sweetener for soft drinks is a combination of saccharin and aspartame.The information that is now available suggests that aspartame usage in moderation is safe because it is consumed at levels that are well below any potential dangerous threshold. The ADI for it is set at 40 mg per kg of body weight. In a lot of nations, including India, aspartame use is legal.
- Acesulfame K: Acesulfame K was one of the non-nutritive sweeteners that was first released in 1967. The potassium salt of 6-methyl-1,2,3-oxathizine-4(3)-one-2,2-dioxide is acesulfame K. It is a 150–200 times sweeter substance than sucrose that is a white,

crystalline powder that is freely soluble in water and not hygroscopic.
- Acesulfame K is a tabletop sweetener as well as an ingredient in soft drinks and gum. There are other food applications being looked upon.
- The existing toxicological information on acesulfame K does not indicate any significant safety concerns.The set ADI value is 9 mg/Kg of body weight. In some nations, like India, its usage as a sweetener is approved with restrictions.

9.13. ANTIOXIDANTS

- Antioxidants are crucial for keeping fats, oils, and fatty meals fresh. You already know how oils and fats work chemically. They are essentially glycerine's fatty acid esters. There are two types of fatty acids: saturated and unsaturated.
- During storage, the unsaturated fatty acids in fats and oils may be subject to oxidation, which can result in the formation of rancidity. Along with the development of rancidity, nutrient depletion, coloration, and even toxic consequences are potential side effects.
- The term "autocatalytic reaction" is frequently used to describe lipid oxidation. It is a complicated reaction that, once it starts, will spiral out of control.The autoxidation reaction, which is essential to glyceride oxidation, can be inhibited or interfered with by foods that include antioxidants. Simply said, they undergo oxidation instead of fats and oils.

- You probably know that tocopherols, which are found in a variety of vegetable oils, have antioxidant properties. Lecithin and ascorbic acid both have antioxidant qualities. However, phenolic compounds—often referred to as phenolic antioxidants—are the main antioxidants commercially employed in foods, fats, and oils. Foods may include some metals like iron and copper, which are potent fat oxidation catalysts and may interact with antioxidants to discolour food. Food acids with the ability to bind these metals include citric acid.
- As a result, the antioxidants are frequently added in addition to citric acid.The four most commonly utilised phenolic antioxidants for fats and oils are tert-butyl hydroquinone (TBHQ), butylated hydroxy anisole (BHA), and butylated hydroxy toluene (BHT).
- Butylated hydroxy anisole (BHA) is a solid that is white and waxy and is typically tableted to prevent caking while being stored. It has a pronounced phenolic aroma and is easily soluble in glycerides and organic solvents but insoluble in water.
- BHA is fairly stable during typical fatty food processing and storage.
- It is seen as having a good carry-through effect as a result. BHA may, however, be lost

in part during deep fat frying because it is volatile at high temperatures.

- BHT is a white, crystalline substance that has been butylated to hydroxy toluene. Additionally, it is insoluble in water and soluble in glycerides.It retains some of its carryover effect but loses some of it due to volatilization at high temperatures. Compared to BHA, BHT is less effective as an antioxidant.
- Propyl gallate is the n-propyl ester of gallic acid, or 3,4,5-trihydroxy benzoic acid. The powder ranges from white to light grey. It is significantly water soluble and poorly soluble in oil. Due to its heat lability, it has relatively low carry-through properties, especially in the alkaline conditions seen in baked goods, despite having very excellent antioxidant capabilities.
- In order to improve storage stability and carry-through protection, propyl gallate is used in conjunction with other antioxidants like BHA.Butyl Hydroquinone (TBHQ)
    - is a white to light tan crystalline solid that has been shown to improve the stability of fats and oils during storage.It is barely soluble in water and just marginally soluble in fats and oils.It has the advantage of not producing coloured compounds with dietary metal ions like iron, unlike other phenolic antioxidants.Fried foods are well-protected by TBHQ during transport.Uses for phenolic antioxidantsAntioxidants are possibly the most often utilised food additive, as was already mentioned.They are utilised in a variety of items, including vegetable oils, meat products, candy and chewing gum, breakfast cereals, and bread goods.Despite their restricted use, antioxidants found in fruit and vegetable products have a significant economic impact.
- Fruit nuts like walnuts, almonds, and cashew nuts are some of them, along with citrus oils and dehydrated potato goods like powder, flakes, and granules.
- All of the phenolic antioxidants mentioned above, with the exception of BHT, have been restrictedly allowed under PFA. Lecithin and ascorbyl palmitate are also acceptable for use in some food products.

9.14. ANTI CAKING AGENTS

- Anti-caking agents are anhydrous substances that are added sparingly to dry foods to keep the product dry and free-flowing and stop the particles from sticking together.
- Anti-caking chemicals work by absorbing extra moisture or by covering particles with a water-repellent coating.
- Dry soup, cake, and biscuit mixes would clump and chunk without anti-caking ingredients, hot chocolate and cappuccino vending machines would not work, and

premixes for manufacturing would be more challenging to utilise.

- Baking powder, table salt, chocolate, milk and cream powders, flour-based mixes, and blended coffee beverages are just a few examples of products that frequently contain anti-caking ingredients. Anti-caking compounds are used during manufacture to help avoid bridging during the packing process, which can lower production rates.Powders can bridge or form an arch above the outlet of a container like a silo, hopper, or mixing vessel when particles interlock or link together.
- One of the most powerful anti-caking substances is silica, sometimes referred to as silicon dioxide. The most prevalent mineral in the earth's crust is silica, which is obtained from naturally occurring quartz. Additionally, it occurs naturally in water and plants. Silica adheres to food particles in powdered foods and prevents clumping. Additionally, silica is absorbed for dl-tocopheryl acetate and pantothenyl alcohol in tableted meals, used as a carrier and a defoamer, and used as a stabiliser in the brewing of beer.
- Another popular anti-caking ingredient, tricalcium phosphate (abbreviated as TCP), is used primarily to stop powered food from caking and lumping as well as to increase fluidity. It is frequently present in instant powders, table salt, spices, powdered milk, non-dairy creamer, and powdered drink mixes. Tricalcium phosphate, which is the calcium salt of phosphoric acid, is also used to raise the calcium content of food, primarily dairy substitutes.
- Several of the compounds with dual uses include:

- Additionally serving as a humectant, sweetener, and texturizer is mannitol (E421).
- Alpha (E460b) and microcrystalline (E460a) cellulose (E460a) are bulking, stabilising, and binding agents.
- Rice husk powder and maize starch are two alternatives to anti-caking agent additives that are available in various markets.One study, for instance, found that adding powdered rice to salt during manufacture as an anti-caking agent at a concentration of 1% might replace other popular anti-caking food additives used in the production of table salt.
- Anti-caking agents benefit businesses other than food, primarily the cosmetic and detergent industries.
- Indeed, it is projected that the great adaptability of anti-agents like silicon and tricalcium phosphate would further reinforce the expanding demand from a variety of sectors.

9.15. PROTECTIVE GASES

- In particular, packaging in a protective atmosphere is a technology that makes it simple to change the composition of the gases that are present in the packages during the packaging process. For instance, it does this by increasing nitrogen, an inert gas, and carbon dioxide, a bacteriostatic gas, to reduce the rate at which food naturally deteriorates due to the presence of oxygen.The gases utilised in this range are all strictly approved as food additives and naturally occur in our air. By adjusting the ratios of these gases in packaging, their properties can be employed to extend shelf life.
- The two main gases utilised are nitrogen and carbon dioxide, while oxygen is also used to package red meat and some varieties of fish. For better food preservation in packaging, gases such as oxygen, carbon dioxide, argon, and dioxide are employed. One of the biggest problems facing the food business has always been the desire from consumers for the preservation of food goods using natural methods. AliSOL is an efficient, effective solution to this demand.

Packaging in a protected environment enables:

- reduce or prevent the use of those chemical compounds used to reduce the main processes of natural deterioration of the product;
- increase the shelf life of fresh goods, even doubling it compared to packing in air;
- Improve production efficiency and the effectiveness of food product distribution.
- Avoid the crushing caused by vacuum packaging to preserve the original appearance of packed food.

9.16. CONCLUSION:

This unit provides information about food additives and preservatives used in food products to increase the shelf life. Food additives like acids, buffer systems and salts, chelating agents, antimicrobial agents,sweeteners,stabilizers and thickeners, fat replacers, firming texturizers, appearance control and clarifying agents, Flavour enhancers,aroma substances,sugar substitutes, sweeteners,antioxidants,Anti caking agents,protective gases are described in detailed.

EXERCISE

1. **Define food additives.**
   ………..
2. **Define food stabilizers**

**……………………………………………………………………………………………
……………………………………….**

3. **Write about artificial seetners**

   **……………………………………………………………………………………………
   ………………………………………….**

4. **Define fat replacers**

   **……………………………………………………………………………………………
   ……………………………….**

5. **Write in brief about antimicrobial agents.**

   **……………………………………………………………………………………………
   ……………………………………………………………..**

6. **Write in berief about flavor enhancers**

   **……………………………………………………………………………………………
   ……………………………………………………………………………………………
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7. **Define anticaking agents**

   **……………………………………………………………………………………………
   ……………………………..**

8. **Write in brief about**

   **……………………………………………………………………………………………
   ………………………………………………………….**

BLOCK IV: PROCESSING OF SPICES, AND FERMENTATION TECHNOLOGY

Block IV deals with the processing techniques of condiments and spices, and process of fermentation.

This block consists of two unit i.e. Unit X and Unit XI, Unit X is Processing techniques of Condiments and spices and unit XI deals with the Processing technology of Fermentation, various fermented products are also discussed in this unit.

STRUCTURE

Unit. X: Forms, Functions, and Applications of Spices

10.16.Spice Blends, Seasonings, and Condiments
10.17.CONCLUSION

OBJECTVES:

After study of this unit srudent will be able to learn about

- Forms and functions of various spices
- Composition of spices
- Role of spices in helath aspects
- Uses in various preparations
- Extraction of volatile and nonvolatile compunds.
- Explain methods of storage of fish mince;
- Discuss on the effect of various parameters influencing storage and shelf life of fish mince; and
- Analyse the influence of various parameters on mince quality.

10. Forms, Functions, and Applications of Spices

10.0. Introduction

The foundation of flavour in food applications is comprised of spices. Spices must be properly understood by food makers if they are to employ them as useful building blocks for successful goods. The Latin word "species," which means particular sort, is where the word "spice" originated. The name refers to the cultivation of all plant parts, such as seeds (such as aniseed, caraway, and coriander), leaves (such as cilantro, kari, bay, and mint), berries (such as allspice, juniper, and black pepper), arils (such as mace), stems (such as chives), stalks (such as lemongrass), rhizomes (such as ginger, turmeric, and galangal), roots (such as lovage

Spices are consumed by people all over the world to increase appetite, flavour, and visual attractiveness of food. Called rempah (Malaysian/Indonesian), beharat (Arabic), besamim (Hebrew), epices (French), kruen tet (Thai), masala (Hindi), specie (Italian), especerias (Spanish), sheng liu (Mandarin), specerjien (Dutch), krooder (Norwegian), or kimem (Ethiopian), spices have been savoured and sought around the world from the earliest times because of their diverse functions.

Due to the rising global demand for authentic ethnic and multicultural cuisines, culinary professionals are constantly looking for "new" and distinctive spice flavourings. For healthy lifestyles and natural means of preventing illnesses, consumers are also looking for natural foods and

preservatives. Therefore, spices are sought after for their therapeutic properties, antioxidant properties, and antibacterial properties.
This chapter discusses the various forms and chemical makeup of spices, their primary and secondary uses, how to prepare them, how to incorporate them into product development, and how to ensure that spices are subject to appropriate quality control.

10.1. Spice Forms and Composition

Spices can be purchased in a variety of formats, including whole, ground, crushed, or pureed varieties as well as pastes, extracts, and infusions. Each shape has unique advantages and disadvantages. The exact use, processing conditions, and shelf life will all influence the form that the food product designer ultimately decides upon.

10.2. Fresh Whole Spices

Fresh spices are commonly used by consumers and chefs to give food a fresh flavour. The flavour, aroma, and texture of ginger, cilantro, sweet basil, or chilli peppers contribute to their fresh flavour. Consumers look to spices for their "fresh" taste, which is initially derived from their fragrance. The volatile part of the spice is what gives off this perfume. It might disappear while being harvested, stored, processed, or handled. Ginger, galangal, cilantro, and basil are a few spices that have varied flavour qualities in their fresh and dried forms. Due to higher concentrations of the pungency-producing gingerol, which during storage degrades to the milder shogoals that are present in greater quantities in dried ginger, fresh ginger is more pungent than dried ginger.

Prepared foods taste more flavorful when made with fresh ingredients, especially when entire spices are freshly ground. Fresh spices have appealing colours and snappy, crispy textures. When freshly ground spices are roasted or cooked in oil, they also develop a strong scent that permeates the dish. This is particularly true of seeds and leaves that are entire or broken, such as bay leaves, kari leaves, or mustard seeds.
Whole spices offer aroma as well as, and most significantly, texture and aesthetic appeal. Due to their highly volatile (essential) oils, several spices, including basil, kari leaf, ginger, or mint, have a potent aroma when they are fresh. At high temperatures, the essential oils vanish quickly.

They can also be lost at room temperature, when the spices are sliced or damaged, or if the processing of the spices is done in an aqueous system.
Even though a product's uneven distribution of whole spices can be problematic, this effect is occasionally sought to generate nuttiness or a feeling of "bite" into a whole spice, such as with whole sesame seeds on a breadstick or ajowan seeds on Indian naan bread. In this way, entire spices can end up being the primary flavour that defines a product. Additionally, whole spices make beautiful garnishes, particularly the green varieties.When subjected to cooking methods like frying or roasting, during which time the whole spice gently cracks open, flavour is retained in whole spices and is released more gradually than it is with crushed spices.

The chemical elements that produce the flavours are distributed differently throughout a complete spice. The core parts of chilli peppers, such the veins and seeds, contain the highest quantities of noxious chemicals.Cooking or processing alters the chemical composition and quantities of many whole spices to varied degrees, which frequently results in different flavour profiles. For instance, the flavour and colour of some chilli peppers are considerably altered by smoking, grilling, or drying them.

As a jalapeno is smoked and dried, its flavour changes.Jalapenos undergo a full flavour and colour shift when they are smoked and dried, giving them a new name: chipotle.After roasting or boiling, spices that don't have a distinct aroma, like bay leaf, chile pepper, or sesame seed, create strong flavours. For dishes with meat, fish, and poultry, mustard seed, star anise, and fagara (a Szechwan pepper) are typically dry-roasted to enhance their flavours.Many spices, including lemongrass, spearmint, basil, and chilli peppers, are freshly mixed and added to liquids like water, oil, wine, or vinegar to create sauces and condiments. Fresh pureed or paste forms should be thoroughly combined before using in sauces, soups, or gravies because they contain potent flavours.

Due to the oil that is typically present in paste form, it can quickly go rancid. Spices are frequently lost their flavours, colours, and textures after storage and lengthy processing, despite consumer desire to use "fresh" spices. Before adding whole spices to processed meals, preliminary preparations are typically made, such as grinding, roasting, or flaking the spices.Fresh spices are more difficult to maintain consistency with because their origin, age, and storage conditions affect flavour. Therefore, by necessity, the kinds of spices that are most frequently employed to create foods or beverages are dry spices and spice extracts. Fresh whole spices are typically utilised in restaurants, at home, and in other smaller-scale applications but are rarely seen in processed meals.A food designer's objective is to create items with the "fresh" character that consumers want while also giving them spice-sensory qualities that can resist processing, freezing, and storage conditions.

10.3. Dried Spices

Due to their lack of seasonal availability, ease of processing, extended shelf life, and lower cost, dried spices are frequently utilised. The majority of the time, processed goods or wholesale use call for these dried forms. Dried spices are available whole, cracked, finely or coarsely ground, and in a variety of particle sizes. To grind spices, mill them into a range of particle sizes. Additionally, the quick air movement and heat produced by the grinding process disperse some volatile oils and even oxidise some natural flavour notes.The same dried spice will impart various flavour impressions in the final product depending on its shape. In food products, ground spices are more easily absorbed than fresh whole spices.

The cellular matrix of the spice is largely destroyed during grinding, which also releases certain volatile oils. Because most of the moisture is removed during drying, the flavour in some spices is enhanced. Due to the loss of the volatile components, this results in a higher concentration of low volatile chemicals that have a stronger flavour but less scent. Compared to fresh spices, dried spices may survive greater temperatures and processing conditions better.

To describe the flavour and feel of an application, use some dried spices. The flavour and texture of garlic bread, onion bagels, or chips are characterised by the presence of garlic and onion, which are available in powder, granules, ground, minced, chopped, and sliced forms in a range of particle sizes. The use of a dried spice will depend on whether it is ground, granulated, cracked, or whole.

Depending on how it will be used, dried spices can be powdered, granulated, cracked, or used whole. Like ground mustard, which only becomes pungent when water is introduced, many ground spices need to be "rehydrated" in order to develop their flavour. When water is added, an enzyme reaction happens and the spice's scent is released. To maintain the pungency or potent flavours of the spice in the completed product, acidulants, oil, or vinegar are additionally added.

Dried spices might be more cost-effective to utilise in processed dishes than fresh spices. For instance, dried leafy spices do not require the same preparation as fresh ones, such as cutting, chopping, or grinding. Additionally, compared to fresh spices, most dried spices retain a higher overall flavour concentration.
For example, one pound of dried garlic has an equivalent flavor of five pounds of fresh garlic.

Environment, climate, soil conditions, time of harvest, and postharvest processing affect the sensory, physical, and chemical properties of dried spices. Depending on where it was cultivated and how it was picked, stored, and processed, the same spice can have various sensory qualities. As an illustration, dried ginger from Jamaica has a more intense flavour than ginger from southern China or India, which has a more subdued lemon-like flavour. Similar to this, the flavour intensity of ground black pepper, which is made from a dried berry called a peppercorn, varies according to where it is from. Tellicherry black peppercorns from India are quite aromatic, but Lampong black pepper from Sumatra is less aromatic but more pungent. In comparison, the Malaysian and Brazilian peppercorns have softer aromas with greater bites.

For the majority of spices, the intervals between harvesting and storage as well as between the time the spice is ground and added to a dish are critical for maximising potency.
Different spices have different flavours and colours depending on how they are handled or processed before being ground, as well as how they are stored before being delivered to the food processor. Spice flavour can easily oxidise, and when processing and storing spices, losses happen.
The aroma and flavour of the majority of spices, including cumin, coriander, and cardamom, are more potent when purchased freshly ground than when purchased preground. The oils in spices have a tendency to volatilize when ground, resulting in scent loss. As soon as they are pulverised, allspice, black pepper, and anise swiftly lose their scent.

In order to maintain colour and flavour,

Sometimes lower temperatures are used for milling spices to better preserve their colour, flavour, and scent. The disadvantage of finely ground spices is that they integrate better in finished products that demand a smooth texture, even if they lose more aroma as they are ground more finely.
Some drawbacks may apply to dried spices. Some have weak flavour strength, which might lead to the completed product discolouring and giving it an undesirable look. For instance, dried ground cayenne can produce uneven flavour and colour changes, occasionally resulting in "hot" areas in food preparations. In order to improve the flowability of dried spices, anticaking chemicals are applied. When particles are sought for aesthetic and textural effects in applications with a high moisture content, like salad dressings or soups, Unless dried spices are sterilised, utilising them poses a significant danger.

10.4. Spice Extractives

Combining taste, scent, and texture creates flavour. The flavours of sweet, piney, sour, bitter, spicy, sulfury, earthy, and pungent come from a spice's overall mix of fragrance and taste, which is primarily owing to nonvolatile ingredients. The overall flavour of a spice is enhanced by its crunchiness, smoothness, or chewiness.
The volatile and nonvolatile oils that give each spice its distinctive flavour are present in spice extractives, which are highly concentrated versions of spices. Spice extractives' volatile components, also known as essential oils, are what give a spice its distinctive aroma. The essential oil component of the majority of spices, which typically varies from 1% to 5% but can even reach 15% in some spices, is what gives them their distinct "fresh" flavour.

The taste or "bite" of a spice is influenced by the nonvolatiles, which also include antioxidants, hydrophilic chemicals, gums, resins, and fixed oils.
Spices like black pepper, chilli peppers, ginger, saffron, and turmeric are treasured for their flavour and colour. The nonvolatile components of spices are responsible for these qualities.
The quantity and ratio of the various chemical elements in volatile oils is what creates the distinct scents of the spices. There may be one, two, or more components in them. Terpene chemicals make up the majority of an essential oil's chemical makeup; these include monoterpenes, diterpenes, triterpenes, and sesquiterpenes, depending on their molecular size.

Monoterpenes are the most volatile of these terpenes and make up the bulk of the terpenes in spices. When the tissues and cells of a spice are broken down through heating, crushing, slicing, or cutting, monoterpenes release potent scents. Sesquiterpenes are most abundant in the ginger and cinnamon families, whereas mint and parsley are the most abundant. Triterpenes and diterpenes are potent and astringent substances.
A spice's flavour, whether it be sweet, hot, sour, or salty, comes from a variety of chemical constituents, including esters, phenols, acids, alcohols, chlorides, alkaloids, and sugars. Esters and sugars provide sweetness; organic acids (citric, malic, acetic, or lactic) provide sourness; cations, chlorides, and citrates provide saltiness; phenols and tannins provide astringency; and alkaloids (caffeine and glycosides) provide bitterness;

acid amides, carbonyls, thio ethers, and isothiocyanates have pungency.

Within a genus or even within a variety, spices' volatile to nonvolatile ratios can differ, resulting in flavour similarities and differences. For instance, the flavours of garlic, onions, chives, shallots, and leeks under the genus Allium vary depending on this ratio. They differ according on the type of spice, its origin, the environmental factors that affect growing and harvesting, as well as the methods used for storage and preparation. Even distillation methods themselves can result in different components due to the loss of high boiling volatiles, the failure to extract some components, or the modification of others.

The amount of nonvolatiles in a spice varies according on its variety, origin, environmental growing conditions, maturity stage, and postharvest circumstances. For instance, depending on the ratio of the various nonvolatiles, the capsaicinoids, the various chilli peppers of the Capsicum group, such as habaneros, cayennes, jalapenos, or poblanos, all give diverse flavour impressions.
Spice extractives are available as dry encapsulated oils (spray-dried powders and dry solubles) and natural liquids (which include essential oils, oleoresins, and aquaresins). Spice extractives are made from freshly ground or coarsely ground spices and are standardised for colour, aroma, and, in the

case of some spices, antioxidant activity. They are used at considerably lower quantities since they are more concentrated than dried or fresh spices. In prepared recipes, these extractives offer greater consistency than dried spices.

10.5. Essential (Volatile) Oils

By grinding, chopping, or crushing the leaf, seed, stem, root, or bark, essential oils like oil of basil, oil of caraway, or oil of black pepper are created. The distillate oil is then recovered using a solvent after being cold expressed, dry distilled, or extracted through distillation (using water, steam, or steam and water). Sometimes a complete spice, such a leaf or bloom, or a broken spice, are used to distil the oil. The nature of the volatiles in the same type of spice can vary depending on the extraction procedure.

The main flavouring ingredients in spices are essential oils. The characterising scent often makes up between 60% and 80% of the total oil in each essential oil despite the fact that each comprises numerous chemical components, sometimes even up to fifteen (Table 2). The main constituents of essential oils are hydrocarbons (terpene derivatives) or terpenes (such as -terpinene, -pinene, camphene, limonene, phellandrene, and sabinene), oxygenated derivatives of hydrocarbons (such as linalool, citronellol, geraniol, carveol, menthol, borneol, f

Table 1 Examples of Characterizing Essential Oil Components in Some Popular Spices

Spice	Components in Essential Oils
Allspice seed	Eugenol; 1,8-cineol; humulene, α-phellandrene
Basil, sweet	Linalool; 1,8-cineol; methyl chavicol, eugenol
Cardamom	1,8-cineole; linalool; limonene; α-terpineol acetate
Dill leaf	Carvone, limonene, dihydrocarvone, α-phellandrene
Epazote	Ascaridol, limonene, para-cymene, myrcene, α-pinene
Fennel	Anethole, fenchone, limonene, α-phellandrene
Ginger	Zingiberene, curcumene, farnescene, linalool, borneol
Juniper	α-pinene, β-pinene, thujene, sabinene, borneol
Kari leaf	Sabinene, α-pinene, β-caryophyllene
Lemongrass	Citral, myrcene, geranyl acetate, linalool

Marjoram	*Cis*-sabinene, α-terpinene, terpinene 4-ol, linalool
Nutmeg	Sabinene, α-pinene, limonene, 1,8-cineol
Oregano	Terpinene 4-ol, α-terpinene, *cis*-sabinene
Pepper, black	Sabinene, α-pinene, β-pinene, limonene, 1,8-cineol
Rosemary	1,8-cineol, borneol, camphor, bornyl acetate
Star anise	Anethole, α-pinene, β-phellandrene, limonene
Turmeric	Turmerone, dihydrotumerone, sabinene, 1,8-cineol
Zeodary	Germacrone-4, furanodienone, curzerenone, camphor

Terpenes, which can be described as floral, earthy, piney, sweet, or spicy, typically contribute to the aromatic freshness of a spice. The main components of a spice's scent are its oxygenated derivatives, which also include alcohols, esters, acids, aldehydes, and ketones. While the sulphur- and nitrogen-containing compounds give the distinctive characteristics to onion, garlic, mustard, citrus, and floral oils, the compounds with benzene structure provide sweet, creamy, and floral notes.
Only barely soluble in water, essential oils can be dissolved in ether or alcohol. In comparison to the ground spices, they offer stronger fragrant effects. With time, essential oils lose their scent.

Essential oils are 75 to 100 times more concentrated than fresh spices in terms of concentration. They are employed in recipes where a strong aromatic effect is sought even though they lack the full flavour profile of ground spices. In the completed product, essential oils are employed at a very low concentration of 0.01% to 0.05%. When consumed internally (by themselves), they can be hazardous to the neurological system, irritate the skin, and even result in miscarriages and allergic responses.
Occasionally, substitute oils taken from a different area of the same spice plant or from a different type are used to enhance or adulterate the more expensive essential oils, but suppliers must match the quality requirements that manufacturers have for these essential oils.

10.6. Oleoresins (Nonvolatiles and Volatiles)

Spices are ground or crushed, extracted with a solvent, and then the solvent is removed to obtain the nonvolatile and volatile flavour components of spices, also known as oleo-resins. Oleoresins contain high boiling volatiles and nonvolatiles, such as resins and gums that are naturally present in spices, giving them the full flavour, aroma, and pungency of fresh or dried spices.
The heat and/or pungency of black pepper, mustard, ginger, and chilli peppers are produced by the nonvolatile ingredients. Acid-amides like capsaicin in red pepper or piperine in black pepper, isothiocyanates in mustard, carbonyls like gingerol in ginger, and thioethers like the diallyl sulphides in garlic and onion can be among these ingredients.

Different heat and/or pungent principles provide various feelings, including spicy, hot, sharp, biting, or sulphurous. Onion and garlic have a sulphurous, pungent flavour, whilst Jamaican ginger has a spicy flavour. Red pepper and white pepper don't have much aroma because they have little essential oils, whereas ginger, black pepper, and mustard provide aroma to bites because to their higher volatile oil concentration. Due to the varied amounts of nonvolatiles, piperine, and chavicine in white pepper compared to black pepper, it tastes different when you bite into it.

In chilli peppers, capsaicin, hydrocapsaicin, homocapsaicin, dihydrocapsaicin, and dihydrohomocapsaicin have all been identified, each of which produces a distinct "bite" feeling in the mouth. The amount of capsaicinoids in each type of chilli pepper varies, which affects how hot it is. Additionally, the experience of heat differs depending on the type of capsacinoid. While cayenne peppers initially burn, habaneros initially bite with a sharp, powerful bite that quickly fades and is replaced by a fragrant sensation.

Table 3 Hot and Pungent Nonvolatiles in Some Spices

Spices	Pungent Components of Spices
Red pepper	Capsaicin, hydrocapsaicin, dihydrocapsaicin, homocapsaicin, dihydrohomocapsaicin
Black or white pepper	Piperine, chavicine
Sansho pepper	Sanshool
Mustard	Allyl isothiocyanate
Horseradish	Allyl isothiocyanate
Ginger	Gingerol, shogoal
Garlic	Diallylsulfide
Onion	Diallylsulfide

Wasabi releases heat sensations differently than mustard, and vice versa. Wasabi releases heat instantly and in the front of the mouth, but mustard and horseradish release heat gradually and at the rear of the mouth, accompanied by a shooting pain in the sinuses. Some of the nonvolatiles that give a spice its pungency are listed in Table 3.

Oleoresins are more challenging to manage than essential oils because they are available as thick pastes and viscous liquids. For easier handling, oleoresins are typically diluted with a solvent such propylene glycol, glycerol, or other oils. For usage in beverages, sauces, soups, pickles, and salad dressings, an emulsifier is added to make it water soluble, or gum is added to make it into an emulsion.

Oleoresins are used in incredibly small amounts due to their high concentration. They are more heat stable compared to essential oils. Oléoresins offer more dependable flavour and colour with less unpredictability when compared to ground spices. They are widely used in high heat applications such soups, salad dressings, processed meats, dry mixes, and spice blends.

Aquaresins, which may dissolve in water, are another name for oléoresins. They are easy to include into recipes that call for water, such as soups, sauces, pickles, or gravies, making them practical to use.

10.7. Other Spice Extractives

Blends of essential oils or oleoresins are used to create liquid-soluble spices for aqueous systems. Essential oil or oleoresin is combined with vegetable oil to create fat-based soluble spices, which are used in mayonnaise, sauces, and soups. Dry soluble spices are made by dispersing standardised extractives on a carrier substance such salt, dextrose, or maltodextrin. They are typically employed in dry blends.

Essential oils and/or standardised oleoresins are used to create encapsulated oils, which are then enclosed in gum arabic or modified starch. Compared to dried, ground spices, these are five to ten times stronger. The typical form of encapsulation is spray-dried flavours.

For the purpose of making liquid spices or extractives easier to handle and use in dry applications, spray-dried spice flavours or dry soluble spices are developed. They consist of a dispersion of spice oleoresin up to 5% or more on a free-flowing base such salt, dextrose, gum arabic, modified starch, or maltodextrin. These spice extractives are encapsulated and employed in high-temperature products including baked goods and retorted foods. At the proper processing temperatures, the spice flavours gradually permeate the product.

For a longer shelf life, essential oils or oleoresins are encapsulated to maintain the full flavour impact of spices. In order to prevent volatile oils from escaping, this technique grinds and wraps the spices in a closed system.

They are encapsulated by combining modified starch, dextrose, maltodextrin, and soluble gum (gum acacia) to form an emulsion, which is then spray-dried under strict humidity and temperature controls. This matrix, which contains the spice extractives, shields the flavour from oxidation and intense heat, extending its shelf life.

Compared to oleoresins, encapsulated oleoresins typically keep the fresh flavours of spices better. Like essential oils or oleoresins, they are fully natural, completely free of particles, and have a clear ingredient label. Since they are water soluble, flavour can be released from them and spread evenly throughout the dish. The noncapsulated extractives are replaced for application in a 1:1 or 1:2 ratio.

An extractive's encapsulation makes it wettable and dispersible in water or oil and reduces manufacturing dusting. The type of carrier and the extractive have an impact on how much extractive can be disseminated on the carrier. The extractive should be applied to the carrier and blended uniformly.

New encapsulating techniques, such coacervation, exhibit improved heat stability and safeguard spice oils during high-heat cooking or extrusion.

Because they are employed in extremely small quantities and produce similar or occasionally better flavour sensations than fresh or dried spices, spice extractives are more affordable than these alternatives. Twenty to forty parts of a pulverised spice are equal to one part oleoresin or aquaresin.

Furthermore, extractives have some heat and freezer stability compared to dried and fresh spices, which are affected by heat and freezing in terms of colour, texture, and flavour. In contrast to dried or fresh spices, which vary in quality and availability throughout the year, extractives are always available and have standardised flavour and colour. Additionally clean of microorganisms and other foreign substances, extractives prevent microbial contamination of the end product.

Natural flavours, natural flavourings, and spice extracts are all terms used to describe spice extractives. Because of their uniform colour, quick flavour release, consistency in flavour and aroma, and stability in high-heat applications, extractives are frequently employed by food makers. The quality and uniformity of products from product development to production can be better managed by employing extractives.

Production can retain consistency from batch to batch while maintaining finished product quality, homogeneity while mixing, and consistency.

For the end product to have the desired flavour profile and to avoid bitterness, the proper usage levels are crucial. Depending on the application, use levels typically range from 0.01% to 0.05% by weight in the finished product. When compared to dried spices, the liquid soluble extractives obtain a more uniform dispersion of colour and flavour. Unlike dried spices, which occasionally mix unevenly in big quantities and leave pockets of flavour and colour, this produces an acceptable appearance in completed goods. Oleoresins and essential oils must first be thoroughly dissolved on a soluble carrier, such as salt, dextrose, maltodextrin, or sugar, before being combined with the other ingredients in a dry seasoning recipe. If not, they won't blend in well with the final product.

Caking of the completed product during storage will result from using the liquid extractives more than is necessary.

The current style is to use spices to create a variety of flavour characteristics. For instance, scientists are breeding habaneros to develop their amazing flavour characteristics with reduced heat. Fresh chilli peppers, such ancho and chipotle, are used by consumers more for flavour than intensity. Since ancient times, Asians and Mexicans have utilised chile peppers to flavour their food and have developed distinctive flavours from chile peppers using various cooking methods. The fleshy, exterior portions of the chilli pepper hold the flavour, which is enhanced when roasted or fried. When chile peppers are fresh, dry, smoked, or grilled, the colour, flavour, and texture profiles change.

The flavour qualities of chile peppers and many other spices are increasingly making up a significant amount of the profile sought as a result of the popularity of these ethnic cuisines.

Table 4 provides a summary of the advantages and disadvantages of various spice forms.

Table 4 A Summary of Advantages and Disadvantages of Different Spice Forms

Spice Form	Advantages	Disadvantages
Fresh whole	Fresh flavor Release of flavor slowly at high temperatures Label friendly	Variability in flavor and color Short shelf life High microbes Unstable to heat Seasonal Availability
Dried ground	Process friendly Longer shelf life	Less aroma Hot spots—flavor and color

	Easy handling and weighing Stronger taste intensity than fresh	Takes more storage space Variability in flavor and color Undesirable specks Seasonal Availability Spice dust contamination during production
Extractives	Standardized flavor and color Uniform appearance, color and flavor Low usage Low microbes Less storage space Available throughout the year	Difficult to handle and weigh Aroma and taste usually not typical of natural spice Loss of volatiles at high temperatures

10.8. Storage Conditions with Spices

Spices should not be exposed to light, extreme temperatures, or high humidity levels while being stored in firmly covered containers. As a result, their freshness is preserved for longer. The components of their flavour and perfume are lost more quickly by heat, dampness, and direct sunlight. Mould growth that leads to spoilage will be aided by moisture and hot temperatures. Spice typically has a moisture content of 8% to 10%. Flavour loss, colour changes, and caking or hardening of the ground spice are all effects of high storage temperatures. The ideal temperature and relative humidity (RH) ranges for storing spices are between 50°F and 60°F (10°C and 15°C). Spices shouldn't be kept in the freezer since every time they are taken out, condensation forms in the containers, hastening the loss of their flavour and aroma.And after each usage, always carefully shut containers. If stored properly, seasonings can last for one to two years, whole spices for about three to four years, and ground spices for about two years. Caking happens and flavour and scent are lost more quickly when anything is exposed to steam. Caking will occur if moisture is introduced into the bottle.

10.9. Functions of Spices

Spices that are edible have many uses in food preparations. They serve primarily as food flavours as well as sources of scent, texture, and colour. Additional benefits that spices offer include preservative, nutritional, and health benefits (Table 5).Spices are made up of nonvolatile, volatile, and volatile ingredients, including fibre, carbohydrates, fat, sugar, protein, gum, ash, and essential oils. Each spice's distinct flavour, colour, nutritional value, and/or health benefits are imparted by a combination of these ingredients. Volatile and nonvolatile flavour components are shielded by a matrix of fibre, protein, carbohydrates, and other cellular components. This cell matrix disintegrates when the spice is chopped, ground, or crushed, releasing the volatile substances.

Table 5 Primary and Secondary Functions of Selected Spices and Flavorings

Taste	Thai basil, black pepper, cardamom, jalapeno, asafetida, lemongrass, star

	anise, kokum, sorrel, chipotle, habanero
Aroma	Clove, ginger, kari leaf, mint, nutmeg, rosemary, cardamom, tarragon, cinnamon, sweet basil, mango, rose petal
Texture/Consistency	Mustard seed, onion, sassafras, sesame seed, shallot, peppercorn, ajowan seed, poppy seed, candlenut, almonds
Color	Annatto, cayenne, paprika, parsley, turmeric, saffron, basil, cilantro, mint, marigold
Antimicrobial	Cinnamon, clove, cumin, oregano, rosemary, sage, thyme, ginger, fenugreek, chile peppers
Antioxidant	Turmeric, rosemary, sage, clove, oregano, mace
Health	Chile pepper, cinnamon, fenugreek, ginger, turmeric, garlic, caraway, clove, sage, licorice

10.10. Primary Function of Spices

10.10.1. Flavor, Taste, Aroma, and Texture

The efficiency of a spice in a recipe or formula is determined by the overall flavour, taste, aroma, texture, or colour the spice adds to food or beverage.

Every spice or flavouring has chemical components that predominate and produce these pleasant properties. Chemical components in spices can produce flavours that range from mild to powerful. The ratio of these chemical constituents determines a spice's distinctive flavour profile.

Spices impart distinctive flavours and odours. They provide descriptions of the six fundamental tastes: sweet, salty, spicy, bitter, sour, and hot. Pungent, umami (brothy, MSG- or soy sauce-like), cooling, and flowery, earthy, woodsy, or green are some of the other descriptors.The different taste sensations are typically felt at different parts of the tongue: sweet is felt at the tip of the tongue, salty is felt at the front sides, sour is felt at the back, bitterness is felt at the back, and heat is felt, depending on the type, at various parts of the tongue.

The majority of spices have multiple flavour profiles. For instance, tamarind has fruity and sour tones, while cardamom has sweet and woody notes. Fennel likewise has bitter and fruity notes.

The physical features of a spice, the manner in which it is used in a recipe (such as whole or ground), and the preparation methods are what determine the texture of the spice.The majority of textural features are obtained by preparing and cooking spices according to methods covered later in this section.

Let's examine the typical sensory properties that each spice or ingredient produces (Table 6). (Remember, though, that descriptions of spice sensory profiles are typically given from a mainstream, Western viewpoint. Western cuisine typically uses blander and gentler seasonings. As a result, Western descriptions may not always correspond to other cultures' sensory perceptions. For instance, although cumin, coriander, and cloves are frequently referred to as spicy, Asians and many other cultures—who are accustomed to eating hot and spicy foods—do not view them in the same way. Although various cultural flavour descriptions are taken into consideration.Although various cultural definitions of taste are taken into consideration, this book typically describes spice tastes from a mainstream American perspective.)

10.10.2. Coloring

Saffron, paprika, turmeric, parsley, and annatto are a few spices that provide foods and drinks both colour and flavour. Consumer preferences for "natural" colorings can be satisfied by spices (Table 7).

Oil-soluble or water-soluble substances are in charge of the colouring in spices. Crocin in saffron, carotenoids in paprika, capsanthin in chiles, bixin in annatto, or curcumin in turmeric are a few examples of common colouring agents in spices. A spice's overall colouring may occasionally be the result of the combined effects of two or more of its colouring ingredients.

Paellas and pilafs are given a stunning yellow colour by saffron, which can be deep red, yellowish orange, or reddish orange in hue.Crocin, a water-soluble terpene glycoside that is unstable to acid and light, is principally responsible for the plant's predominant yellow colour. When crocetin is hydrolyzed, a deeper shade of colour results. Despite being a recognised natural colour in the US, its use is constrained by its high price. In many nations, safflower is widely used in place of saffron, however it is not accepted in the United States.

Table 6 Typical Sensory Characteristics of Spices

Sensory Characteristic	Spices and Other Flavorings
Sweet	Green cardamom, anise, star anise, fennel, allspice, cinnamon
Sour	Sumac, caper, tamarind, sorrel, kokum, pomegranate
Bitter	Fenugreek, mace, clove, thyme, bay leaf, oregano, celery, epazote, ajowan
Spicy	Clove, cumin, coriander, canela, ginger, bay leaf
Hot	Chile peppers, mustard, fagara, black pepper, white pepper, wasabi
Pungent	Mustard, horseradish, wasabi, ginger, epazote, garlic, onion, galangal
Fruity	Fennel, coriander root, savory, tamarind, star anise
Floral	Lemongrass, sweet basil, pandan leaf, ginger flower
Woody	Cassia, cardamon, juniper, clove, rosemary
Piney	Kari leaf, rosemary, thyme, bay leaf

Cooling	Peppermint, basil, anise, fennel
Earthy	Saffron, turmeric, black cumin, annatto
Herbaceous	Parsley, rosemary, tarragon, sage, oregano, dillweed
Sulfury	Onion, garlic, chives, asafetida
Nutty	Sesame seed, poppy seed, mustard seed, whole seeds (ajowan, cumin)

The ginger family member turmeric is frequently referred to as "Indian saffron." When the root is dried and powdered, it produces a yellowish-orange coloured liquid. In salad dressings, pickles, mustards, soups, and sauces, it serves as a natural food colour. Curcumin, a diketone that makes up 3% to 7% of this spice, is what gives it its colour. The amount of curcumin in turmeric varies depending on where it comes from, with Allepey (India) turmeric having a higher concentration than other types.

Turmeric is susceptible to light and alkaline conditions, and its colour ranges from a bright orange yellow to a reddish brown. It can be utilised in products with a pH range of 2.5 to 6.5 and high heat products.In a pH range from acid to neutral, it is yellow, but in an alkaline range, it is reddish brown. When cooked in an iron pan, its colour will fade.

The mild to smoky dried red pepper is used to make paprika. The mild paprika, which gets its vivid red colour from a variety of carotenoids, is commonly used in American cuisine. About 35% of all carotenoids are capsanthin, 10% are violaxanthin, 6% each are cryptoxanthin and capsorbin, and 2% are other carotenoids. Capsanthin has a deep red colour, is oil soluble, and is heat resistant. Through oxidation, which is accelerated by light and high temperatures, paprika powder loses its colour.Its oleoresin, which has a reddish orange hue and is utilised in crackers, salad dressings, spice blends, and snack foods, is more resistant to light and heat.

Annatto is made by grinding the seeds. It comes in shades ranging from orange to golden yellow and is used in cheddar cheese, baked goods, and occasionally in blends with paprika and turmeric oleoresins. Its colouring is a result of the water and oil soluble pigments norbixin and bixin, which are stable between pH 5 and pH 14. Its colour is heat-resistant but less light-resistant.

Table 7 Coloring Components of Selected Spices

Spices	Coloring Component	Type of Color
Saffron	Crocin	Yellowish orange
	Crocetin	Dark red

	Beta-Carotene	Reddish orange
Paprika	Carotenoids:	
	Capsanthin	Dark red
	Violaxanthin	Orange
	Cryptoxanthin	Red
	Capsorbin	Purplish red
	Beta-Carotene	Reddish orange
	Lutein	Dark red
	Zeaxanthin	Yellow
Chile pepper	Beta-Carotene	Reddish orange
	Cryptoxanthin	Red
	Capsanthin	Dark red
	Capsorbin	Purplish red
Turmeric	Curcumin	Orange yellow
Parsley	Chlorophyll	Green
	Lutein	Dark red
	Neoxanthin	Orange yellow
	Violaxanthin	Orange
Annatto	Bixin	Golden yellow
	Norbixin	Orange yellow
Safflower	Carthamin	Orange red
	Saflor yellow	Yellow

In order to obtain the colouring matter, the colouring components of essential oils are often extracted with ethanol or other organic solvents. The vivid yellow, red, and orange hues in processed foods and beverages are created using natural colours made from paprika, saffron, annatto, and turmeric extracts combined with emulsifiers (polysorbate 80). They are accessible as water-dispersible extracts as well as oil-soluble (oleoresin) forms. These extractives will lose colour as a result of exposure to trace metals, oxidised fats and oils, harsh light, and oxygen.

10.10.3. Secondary Functions of Spices

The importance of spices' secondary effects is increasing along with the public's preference for natural or organic foods and non-pharmaceutical treatments for illness. Spices have long been used to boost energy, improve digestion, reduce stress, and stimulate the appetite. When spices are used to improve the flavour of processed meals instead of salt, fat, or sugar, they can also help with nutrition. Spices can be employed as preservatives in food goods, allowing for a more "natural" or amiable label on processed meals.

10.10.4. Spices as Preservatives

Spices have a long history of being used as preservatives, antimicrobials, and antioxidants. Egyptians, Romans, Indians, Greeks, Chinese, and Native Americans were just a few of the ancient civilizations who utilised them to fumigate cities, embalm the kings, preserve food, and fight against diseases and infections.

10.10.5. Spices as Antimicrobials

Egyptians employed spices to preserve food as early as 1500 BC. Prior to the invention of refrigeration, spices were utilised in Europe, the Middle East, and Asia to preserve meats, fish, bread, and vegetables. To prevent food from spoiling, spices were employed alone or in conjunction with smoking, salting, and pickling. The Romans preserved meats and sausages with cumin and coriander, and fish sauce with dill, mint, and savoury. Garlic was used to keep food from going bad by the Greeks, and ginger, garlic, cloves, and turmeric were used to keep meats and fish from going bad in India. Cinnamon, cumin, and thyme were employed in mummification in ancient Egypt. In Indian, African, Indonesian, and Thai villages, spices are still used to preserve food.Additionally, spices have been employed for medicinal and antibacterial purposes. Spices like cinnamon, garlic, and oregano were utilised to treat cholera and other infectious disorders during the Middle Ages. Clove, mustard, and cinnamon were discovered to have antibacterial properties in the late nineteenth century. The study of spices as potential natural antimicrobials, such as ginger, garlic, fenugreek, coriander, turmeric, and clove, continued throughout the 20th century. This research is still ongoing today.

Strong antimicrobial action can be found in aldehydes, sulphur, terpenes and their derivatives, phenols, and alcohols. Spices have significant, moderate, or negligible bacterial inhibitory action (Table 8).According to research from Cornell University, the following spices destroy all bacteria: garlic, oregano, onion, and allspice; thyme, cinnamon, tarragon, and cumin; chilies; and black and white peppers; ginger; anise; and celery seed; up to 80% of germs. According to research from Kansas State University, clove, cinnamon, oregano, and sage inhibit the growth of the gastrointestinal disease-causing Escherichia coli O157:H7 bacteria in raw meat. Dodecenal, which is present in coriander seeds and leaves, kills Salmonella in meats, according to other recent studies.

One spice alone may not be as efficient a preservative as a mixture of spices. Different microorganisms react differently to different spices. Spices can affect gram-positive bacteria more than gram-negative bacteria.Compared to Eschrichia (E) coli bacteria, Bacillus (B) subtilis and Staphylococcus (S) aureus are more sensitive. While certain spices, like allspice and coriander, have very particular uses, others, like rosemary and sage, can work as general-purpose antimicrobials.

Table 8 Spices as Antimicrobials

Spice	Effective Component	Microorganism[1]
Mustard	Allyl isothiocyanate	*Escherichia(E) coli, Pseudomonas, Staphylococcus(S) aureus*
Garlic	Allicin	*Salmonella typhii, Shigella dysenteriae,* molds, yeasts
Chile pepper	Capsaicin	Molds, bacteria
Clove	Eugenol	*E. coli* 0157:H7, *S. aureus, aspergillus,* yeast, *acinetobacter*
Thyme	Thymol, isoborneol, carvacrol	*Vibrio parahemolyticus, S. aureus, Aspergillus*
Ginger	Gingerone, gingerol	*E. coli, Bacillus(B) subtilis*
Sage	Borneol	*S. aureus, B. cereus*
Rosemary	Borneol, thymol	*S. aureus, B. cereus*
Coriander	Dodecenal	Salmonella

Notes:
1 1998; Kenji and Mitsuo.

Some spices' essential oils have a deterrent impact on germs and fungus that are present in meats, sausages, pickles, breads, and juices. Some of the ingredients utilised as antimicrobials include eugenol in cloves, cinnamaldehyde in cinnamon, allyl isothiocyanates in mustard, thymol in thyme, carvacrol in oregano, linalool in coriander, and allicin in garlic.

Nonvolatile oils from the more potent spices, like gingerol in ginger, piperine in black pepper, capsaicin in red peppers, and diallyl sulphide in garlic, have also been proven to have potent antibacterial activities.

To be effective as antimicrobials, spices must be employed in large quantities, however this will affect the flavour of food products. The amount of spices that are normally added to Western-style foods is typically insufficient to totally block germs, but it may partially limit deterioration. At the dosages employed, spice extracts are effective against some germs. The essential oils of thyme (thymol), anise (anetol), and cinnamon (eugenol) prevent the development of mould and aflatoxin.

10.10.6 Spices as Antioxidants

To assist counteract the poisons produced by our contemporary society, spices can be added to food. The creation and proliferation of free radicals in the human body are triggered by heat, radiation, UV light, tobacco smoke, and alcohol. Human cells are damaged by free radicals, which also reduces their resistance to diseases including cancer, ageing, and memory loss. Numerous spices contain substances that function as antioxidants and defend cells from free radicals (Table 9).

Depending on the meal they are in, many spices have greater antioxidant effects than others. Spices work better when combined with other spices or antioxidants like tocopherols and ascorbic acid. Spices contain phenolic diterpenes and diterpenes, which are naturally occurring phenolic chemicals that are helpful against oxidative rancidity of lipids and colour deterioration of the carotenoid pigments.

Table 9 Spices as Antioxidants

Spice	Chemical Component
Rosemary	Carnosol, carnosoic acid, rosmanol
Sage	Rosmanol, epirosmanol
Turmeric	Curcumin, 4-hydroxycinnmoyl methane
Clove	Eugenol
Oregano	Phenolic glucoside, caffeic acid, rosmarinic acid, protocatechuic acid
Mace and nutmeg	Myristphenone
Sesame seed	Sesaminol, δ-tocopherol, sesamol
Ginger	Shogoal, gingerol

By reducing the rate at which lipids and enzymes oxidise, spices can reduce rancidity and increase shelf life. With exposure to oxygen or the air, fats decompose into peroxides, which have a rancid flavour, followed by aldehydes and alcohols. Spices can stop oxidation by "scavenging" or obstructing free radicals.

Today, spices can be employed commercially as natural antioxidants in foods due to consumer demand for "natural" products. The antioxidant effects of sage, rosemary, oregano, thyme, cilantro, and marjoram are shown to be stronger than those of other spices. As natural antioxidants in food, rosemary and sage are currently used, and cilantro and other spices are being investigated.

The antioxidants from rosemary and sage can be employed in lard, sausage, instant potatoes, seasoning blends, salad dressing mixes and dry or oil-soluble solubles. Prior to freezing, they are applied as sprays, dips, or surface coatings to minced poultry, shellfish, or meats to prevent the development of "warmed over" flavours from cooking and reheating. For snack foods, they are included into the dough, atomized on the snack's surface, or added to the frying oil. They are also included in glazes and injection marinades for meats. Due to their great heat stability, they can survive temperatures associated with extrusion, spray-drying, or baking.

Sage and rosemary are the most effective spices for preserving the red colour of processed meats because they stop the fats and oils in them from losing their flavour and colour. The antioxidant benefits of sage and rosemary are due to their flavonoids, diterpenes, and triterpene content. They have better antioxidant qualities than BHA or BHT. Thyme, turmeric, oregano, ginger, clove, majoram, red pepper, mace, sesame, and nutmeg are further useful spices.Strong antioxidants with pork, lard, and soybean oil have been found to be rosemaryol, caffeic acid, myristphenone, curcurmin, eugenol, thymol, and sesaminol in clove, thyme, oregano, ginger, turmeric, nutmeg, and sesame seeds.

10.11. Emerging Functions of Spices

10.11.1. Spices as Medicines

Spices are being highlighted as essential elements for great low-fat or low-salt cuisine as well as a natural way to promote wellbeing and improve health as a result of the increased emphasis on healthy eating. People would rather consume a "natural" food product than take medication or other medications. Spices are drawing growing interest from consumers as medical benefits are well understood.

These healthy food can be produced with spices. Phthalides, polyacetylenes, phenolic acids, flavanoids, coumarins, capsacinoids, triterpenoids, sterols, and monoterpenes are some of the active ingredients in spices that have been shown to have positive effects on both physical and mental health.

Spices like celery, parsley, ginger, turmeric, fenugreek, mint, licorice, garlic, onion, mustard, horseradish, and chile pepper can be used to stimulate the production of enzymes that detoxify carcinogens, prevent the synthesis of cholesterol and oestrogen, lower blood pressure, increase immune activity, and stop the growth of tumours.

Spices have been used to treat illnesses and prevent them since ancient times, and not just by Indians and Chinese people but also by Latinos, Africans, Egyptians, and Greeks.Western researchers have isolated the active ingredients in spices recently to investigate their potential health-promoting properties: Turmeric inhibits tumours, heals wounds, acts as an antidepressant, and fights Alzheimer's; licorice treats gastric and duodenal ulcers; rosemary, sage, and basil fight against tumours; chile peppers inhibit blood clotting, stimulate digestion and circulation, induce perspiration, and reduce pain; ginger prevents motion sickness and helps with digestion and stomach ulcers; garlic lowers cholesterol and high triglycerides, prevents colds and flu.

Using essential oils, aromatherapy can excite or calm the body, induce particular moods, soothe respiratory and cold symptoms, and reduce muscle discomfort. Through receptors in the mouth and nose, the vapours are inhaled to release neurochemicals in the brain that have the intended effects. The first type of aromatherapy is cooking with spices because their aroma can stimulate gastric secretions that increase appetite. To ease stress and pain, spices can also be administered to the skin, joints, and muscles as massage oils or balms. There are several instances of spices having positive health effects.

Spices that were traditionally used to treat illnesses and prevent diseases will be promoted in the United States and other countries due to the growing trend of using foods as nutraceuticals to increase energy and enhance health.

To better comprehend how and why spices are employed as remedies by numerous civilizations around the world, let's have a look at conventional medical practises. This will also aid in comprehending the underlying principles behind the diverse flavours offered by spices and the variety of tastes encountered in an Asian cuisine.

10.11.2. Traditional Medicine

Many ancient cultures utilise spices to increase energy, reduce stress, strengthen the neurological system, promote digestion, soothe the symptoms of the common cold and headaches, and treat a variety of illnesses. By employing genuine spices and appropriate preparation and presentation techniques, a food designer can experiment with novel culinary ideas that combine flavour and "cure".

Europeans have employed oils derived from leafy spices or plants to promote their physical, emotional, and spiritual well-being. For example, they have used these oils to reduce anxiety, ease muscle aches, and treat a variety of illnesses like colds and fevers. Egyptians and Middle Easterners both employed spices for a variety of therapeutic and beauty purposes. With some roots in ancient Greek and Roman medicine, the Unani Herbal Medicine of the Middle East shares many traits with traditional Indian and Chinese medicine.

The therapeutic tenets of traditional Ayurvedic medicine are the foundation of Indian cuisine. In order to obtain wellness, this Ayurvedic concept of eating prescribes the blending and preparation of spices as well as how foods are balanced. Ayu, which means life, and veda, which means knowledge, are combined to form the word ayurveda. In India, this form of medicine has been used for more than 5000 years. It focuses on wellness and prevention and examines the root causes of illness as well as how it manifests.

It is founded on the principle that by eating the correct meals, practising deep breathing techniques, and living a healthy lifestyle, the life force, or prana, can readily flow into each and every cell of the body. The components in an Ayurvedic meal are picked not just for their flavour but also to ensure the harmony and wellbeing of the body and mind. The primary focus of Ayurveda is the pursuit of mental, physical, and emotional equilibrium.

Table 10 Foods and Contributing Tastes (Rasas)

Tastes (Rasas)	Example Foods
Sweet	Anise, fennel, cumin, coriander, sugar, butter, honey, jaggery, rice, legumes, fruits, milk, cardamom, coconut, most grains, ghee
Sour	Kokum, pomegranate, tamarind, tomato, lemon, citrus, grapefruit, fermented foods (yogurt, pickles, miso, soy sauce), vinegar
Salty	Salt, seaweeds, vegetables (high moisture)
Bitter	Fenugreek, turmeric, clove, cinnamon, endives, lettuce, purslane, bay leaf, ajwain, chicory
Spicy/pungent	Chile peppers, ginger, garlic, horseradish, mustard, onion, black pepper
Astringent	Asafoetida, teas, licorice, legumes, fenugreek, cauliflower

The five elements of earth, water, fire, air, and ether are used to categorise spices, just like in the classical Greek and Roman conceptions of medicine. According to Ayurveda, food is divided into six flavours or rasas (Table 10). Numerous foods and spices have multiple tastes. For instance, fennel seed has a sweet and cooling flavour while fenugreek seed has a bitter taste as well as astringency. As a result, each spice contributes to a different taste (see Table 10). Other spices might be looked into for rasas to add more variety. Understanding and using Ayurvedic medicine require an understanding of these rasas. They have an impact on our health, disposition, and digestion.

Table 11 Doshas and Respective Personalities

Doshas	Qualities
Vata	Quick thinking, creative, flexible, nervous
Pitta	Determined, strong willed, fiery, passionate
Kapha	Good endurance and stamina, heavy, stable, relaxed, tolerant

All six tastes, or rasas, should be present at every meal in order to preserve perfect balance and be adequately nourished. This explains the intricate spice blends and rich flavour of Indian cuisine. According to each person's constitution or doshas, these tastes must be balanced in the meal to harmonise the body. When a person's constitution and their diet are out of balance, illnesses and diseases can develop. The five elements of energy—earth, fire, air, space, and water—have three basic constitution types or doshas (Table 11). A person typically has influence from three doshas, with one or two of them predominating. The predominant dosha or doshas for that person are determined by which dosha or doshas has the strongest traits.

Table 12 Spices that Balance and Reduce the Doshas

Doshas	Natural Taste	Spices for Balance	Spices to Reduce
Vata	Bitter	Salty, sour, sweet	Pungent, bitter, astringent
	Astringent, pungent	Cardamom, fennel, anise, tamarind	Ginger, asafetida Chilies, fenugreek
Pitta	Sour, salty, pungent	Sweet, bitter, astringent	Pungent, sour, salty
		Asafetida, ginger, cardamom, cinnamon, fenugreek	Chilies, salt, tamarind Garlic
Kapha	Sweet, salty, sour	Pungent, bitter, astringent	Sweet, salty, sour
		Turmeric, fenugreek, mint, mustard, clove	Salt, anise, fennel, tamarind, cardamom

These doshas govern the functioning of our mind-body sysem. They have overall control of th system in our body. Several spices and flavourings are added to our food to balance and harmonise our doshas. Each of these doshas was born with particular innate tastes. The six tastes, or rasas, have a beneficial effect on the doshas by elevating one type of dosha while lowering the others. Ayurvedic cuisine teaches us to use ingredients and seasonings whose tastes balance our unique doshas in order to maintain optimum health. The use of spices in ayurvedic cooking enhances flavor while also enhancing its overall therapeutic value and removing any unfavourable health effects. Indian cuisine places a strong focus on the need for healthy eating.

Indian cuisine focuses that food must be properly digested in order for it to be healthy for the body. Foods might be heavy or light, moist or dry, hot or cold. Hot food will hasten digestion whereas cold food will slow it down. Every meal should contain a balanced balance of hot and cold foods to promote healthy digestion and stave off illnesses. The way Indian food is served at a typical dinner serves to illustrate these notions. Rice or bread (chappati, naan, or dosai), presented in a variety of little silver bowls on a thali or tray, is the traditional vegetarian supper. They consist of hot and spicily braised vegetables, two peppery lentil stews called sambar, hot and sour rasam, and refreshing, minty cucumber raita.

In order to create "harmony" in the body, the "hot" spicy veggies, the "hot" sour broth, and the "cold" raita balance one another. The hot lentil stew brighten up the bland neutral bread or rice, while the crisp mango pickle complements the softly textured vegetables. Additionally, a healthy equilibrium in our bodies is created by the order in which the various side dishes are consumed with rice. These ideas for meal presentation can be used by food designers today to create enticing and well-balanced meals.

In the past, nutrition, medicine, and food have all been integrated in China. Even today, mixtures of spices are used to create tonics that heal ailments and nourish and fortify the body. Chinese traditional medicine follows a similar five-taste system to Indian Ayurvedic medicine: sweet, salty, bitter, sour, and scorching hot. Chinese cuisine has a pleasant taste and is healthy because of the perfect balancing of these many tastes with the suitable textures and colours. Major physical organs are also connected to the five tastes. For instance, the spleen (a yin organ) and stomach (a yang organ) are connected to sweetness; the liver (a yin organ) and gall bladder (a yang organ) are connected to sourness; and the lungs and large intestine are connected to spice.

Each flavour has an impact on the Qi or (chi), an unseen life force that travels through the body via certain channels, much like the prana in Ayurveda or the ool in Mayan healing practises. Harmony and good health depend on the five tastes being balanced properly. Illnesses develop when Qi "gets stuck" or does not circulate properly. Stimulants like food, acupuncture, or acupressure can "unstuck" qi.

The concepts of yin (cold) and yang (hot) are used to explain the various tastes as well as the movement of Qi. Yin and yang are related to the movement of Qi within our bodies. Similar to how hot and cool are in Indian culture, yin and yang are fundamental concepts in Chinese culture. They are comparable to opposites like female and male, moon and sun, and so on. They describe the position, motion, and operation of Qi. The movement in the body is contraction and flow downward and inward for yin, and expansion and flow upward and outward for yang. One cannot exist without the other, and in culinary pairings, yin always comes after yang and vice versa. Spices also produce movement, same as yin and yang do.

Chinese cuisine strikes a balance between yang meals, which are more spicy, hotter, drier, and acidic, and yin foods, which are nourishing, cooler, softer, moister, and alkaline. Seafood, melon, fruits, asparagus, tofu, bland and moist vegetables (seaweed and watercress), steamed dishes, and water are examples of yin foods. Other yin foods include water. Chillis, ginger, garlic, sesame oil, fatty meats (such mutton and pork), deep-fried dishes, and strong alcoholic beverages are examples of yang foods. While yang spices are energetic and speed up metabolism, yin spices are sedative and slow down metabolism. The yin and yang should be balanced to maintain the body's homeostasis and wellness. Because rice is a neutral food, it acts as the focal point of a meal.

Based on this well-being principle, spices are used in the preparation and cooking of food. The foundation of a Chinese dinner is the harmony of yin and yang with contrasting flavours and textures while cooking and at the dining table. To control an ingredient's level of heat or cold while cooking, other substances or spices are used. Tofu or seaweed, for instance, may be balanced in terms of how it affects the body by adding sesame oil and chilli peppers, and ginger-flavored pork may be balanced by adding sugar and anise.

Cooking methods can also be categorised as hot or cold. In contrast, steaming or slow simmering imparts a "cooling" effect. For instance, grilling or deep frying imparts "heat" to food.

The person's health is another consideration. A feverish person won't consume warm or hot foods. She requires cooling elements to keep her system in balance. Seasons have a significant role in balancing the components of health. Spices that cause an upward and outward movement (yang spices) are preferable for the flow of chi during the cold season, whereas yin spices, which cause a downward and inward movement, are preferable during the summer.

Traditional Asian societies have used spices for their therapeutic benefits in addition to dietary ideologies that emphasise balance in order to enhance wellbeing. In contrast to Western cuisine, Asian cuisine uses a lot of spices to flavour foods on a regular basis. Western experts are currently researching and evaluating many of these spices for their beneficial medicinal or pharmacological qualities.

Many traditional cultures link the therapeutic and medical benefits of spices to the use of the whole spice or a blend of complementary spices. A synergistic impact is also produced by the delivery system used for consumption. In order to provide therapeutic benefits, spices are added to milk, tea, vinegar, salt, hot water, or sugar in addition to being used in cooking. For instance, turmeric paste is added to milk and drunk to lessen coughs and colds, while chilli peppers are added to milk as a drink to lessen swellings and tumours, cinnamon is added to sugar and taken to prevent tumours, and so on.

10.11.3. Modern Medicine

Spices are drawing growing interest from consumers as medical benefits are well understood. Many Asian and Western investigations have identified active chemicals in spices that have therapeutic advantages using cutting-edge research techniques (Table 13). Sulphides, thiols, terpenes and their derivatives, phenols, glycosides, alcohols, aldehydes, and esters are some of the phytochemicals (or active ingredients) found in spices. For its numerous medicinal benefits, turmeric has been studied and utilised as a wonder drug. The active ingredients in turmeric are curcumin and curcumene. Turmeric has anti-inflammatory properties by reducing histamine levels; protects the liver from toxic substances; prevents platelets from clumping together, improving circulation and preventing arteriosclerosis; protects against free radical damage; prevents cancer; acts as an antipeptic ulcer and antidyspepsia agent;and mends injuries. Curcumin has been demonstrated by UCLA researchers to reduce the growth of accumulated plaque deposits that are a major factor in the progression of Alzheimer's disease, and even to eliminate them. Trigonelline in fenugreek seeds reduces rise in blood sugar, allicin in garlic decreases cholesterol, capsaicin in chilli peppers protects blood clotting, and gingerol in ginger helps with digestion. More studies are being done on spices in general.

Table 13 Reported Therapeutic Effects of Spices

Spice	Chemical Component	Medicinal Value
Turmeric	Curcumin	Anti-inflammatory; antitumor (inhibits tumor initiation and promotion); prevents Alzheimer's
	Curcumene	Antitumor
Ginger	Gingerol Shgoal Gingeberane *Bis*-abolenenan Curcumene	Digestive aid for stomachaches, indigestion, stomach ulcers Prevents bloating and vomiting
	Gingerol	Antitumor
	Shogoal	Enhances gastrointestinal mobility Inhibits cholesteral synthesis
Fenugreek Seed	Trigonelline	Arrests cell growth and prevents hypoglycemic effect
	Diosgenin	Synthesis of steroid drugs and sex hormones
Seed and Leaf	Soluble dietary fiber (galactomannan) saponins, diosgenin, protein	Improved glucose tolerance (reduces plasma glucose levels), lowers cholesterol and triglyceride (decreases bile secretion)

Garlic	Allicin	Breaks down blood clots, prevents heart attacks, prevents gastric cancer
	Glutamyl peptides	Lowers blood pressure and blood cholesterol
	Allicin, diallyl	Inhibits platelet aggregation
	Sulfide, s-allyl	Inhibits platelet aggregation
	Cysteine	
Licorice	Glycyrrhizin	Treats gastric and duodenal ulcers, prevents coughs and colds, treats chronic fatigue syndrome

Notes: * Information taken from Herbs, Botanicals and Teas by G. Mazza and B. D. Oomah, editors, Technomic Publishing Co., Inc., Lancaster, PA, 2000.

There are still unsolved questions despite the identification of many phytochemicals in spices that have therapeutic properties. Is the whole spice, as it has historically been used, the cure or are phytochemicals the only beneficial healing agents? Is it possible to increase or decrease a spice's ability to heal by combining it with other spices or with substances like water, sugar, tea, milk, protein, or starch? Does the fresh form of a spice, like ginger, which is utilised in Ayurvedic medicine, have a different healing effect than the dry form?

Last but not least, it should be kept in mind that societies who employ spices as traditional medicines eat them at far higher rates than Western societies. In many cultures, "spiced up" dishes are consumed everyday at every meal. Additionally, it is not a regular practise in the West for "spice cures" to be consumed through infusions in teas, milk, coffee, water, and other beverages. Spices and other flavourings can be investigated as integrative or complementary medicines to fulfil the demands of today's customer.

10.12. Spice Preparation

To release their distinct flavours, spices must be ground, sliced, roasted, toastied, fried, or boiled. To get the best flavour from other spices, just like when roasting garlic, sautéing onions, or sautéing mustard, we must use the proper cooking methods.Many ethnic communities around the world prepare their spices to suit certain applications and to produce completely diverse flavour profiles. To maximise flavour and provide a wide range of flavours, spices are dry-roasted, fried in oil, deep-fried, simmered, pickled, braised, grilled, or boiled in water. Heat typically intensifies, changes, or otherwise improves the flavour of spices. Additionally, cooking methods are covered in Chapter 6, "Emerging Flavour Contributors."

While some spices must be added towards the end of cooking or right before serving, others are more stable to heat and can be cooked at higher degrees. Until the spice is sliced or roasted, which causes enzymatic and other reactions that release these distinctive flavours, certain pungent spices do not offer any hot or sharp feelings.. For instance, before their pungency can be tasted, entire onions must be chopped, whole black pepper must be cracked, ginger must be diced, and crushed mustard flour must be "wet". Sesame seeds, star anise, and bay leaves are examples of spices that don't have a strong flavour but do when dry-roasted, braised, or simmered. Simmering beef, steamed chicken, and braised fish are all prepared using star anise, a common ingredient in Chinese cuisine. The flavours of ground spices are further enhanced by cooking.

Many civilizations employ wine or other alcoholic beverages to maintain the spice scent because alcohol makes spice volatiles soluble. For greater flavour retention, spices are frequently sautéed in oils prior to being added to the completed product because the volatiles are oil soluble. For instance, before adding other ingredients, Indian cookery calls for sautéing, toasting, or roasting spices in oil. A spice loses any remaining moisture when it is dry roasted or grilled, which changes the spice's flavour and texture profile and gives the final dish, such as curries or chutneys, a stronger flavour. When entire spices are freshly ground before use, more potent scents and overtones result.

In order to release their flavours, spices like bay leaf, coriander, or cinnamon are frequently used in European and North American cultures by steaming or simmering them in water. However, South Asians prepare whole and ground spices like cumin, coriander, fennel, cardamom, mustard seeds, clove, cinnamon sticks, nigella, and ajwain by roasting (dry or in oil), braising, or sautéing them before adding them to curries and condiments. Even leafy spices, like kari leaf, are occasionally cooked in oil to add additional crunch and a roasted flavour. These prepared spices are what give many South Asian cuisines their savoury and fragrant flavours. Indians typically braise fresh kari leaf to eliminate its bitter green taste, toast mustard seeds in oil to enhance their flavour, and saute asafetida to enhance the flavour of other ingredients.

These methods of preparation tend to slightly crack open the whole spice, releasing its flavours into the frying oil or starting to slowly release its volatiles when added to cuisine. Depending on the spice, whole spices and ground spices are often roasted for one to two minutes, or until they start to get a light brown colour. Past the point at which they should be cooked, they turn bitter and unpalatable.

Many enticing flavours can be produced by smoking, tarkaring, tumising, or bagharing jalapeno, mustard seeds, crushed coriander, or cumin seeds. Spices are tarkared or bargared in India to create a wide range of flavour profiles that either increase, modify, or simply enhance flavours. For instance, cumin and fenugreek seeds are dry roasted for making South Indian dals and sambars, while mustard seeds are fried in hot oil until they "pop." Indian cuisine frequently involves "saute-ing" entire spices in oil before adding the spice-oil mixture to the entrée. This technique is known as tarkaring. The ground spice used in bargharing is fried in oil or covered with oil, vinegar, wine, or any other liquid specified in the recipe to create a thick paste, which is then heated until fragrant. next other.

To produce more aromatic and potent flavours, tumising is a slow stir-frying technique used with wet spice combinations or spice pastes. It is done with continual stirring at lower cooking temperatures. When the oil in which the spices were cooked separates or seeps out of the tumised mixture or sauce, the cooking process is finished. For instance, in Malaysia, Myanmar, Singapore, and Indonesia, fresh or dried chile peppers are mixed with shallots, lemongrass, and other spices, which are then tumised in oil to make a fragrant dish called "chilli (cili) boh." Then, everything from laksas and soups to sandwiches, salads, and vegetable curries are flavoured with this sauce.

In order to create heightened flavour profiles, fire-roasted chile peppers, oven-roasted garlic, or grilled onions have become standard in the US. Holding the chilies over an open flame until the outer skin blisters and chars is the process for fire roasting. The soft, tasty product is then left when the charred skin is removed. Then, to provide sauces, soups, spreads, stews, or salad dressings a richer scent and smokey undertones, this product is added. Today, the focus is on food preparation methods using spices to achieve the best flavours due to the growing impact of South Asian, Southeast Asian, and Mexican cuisines.

Some spices can withstand heat better than others, and some are put towards the end of cooking. When different spices are added at the right periods or stages of cooking, each spice retains its distinct flavour and the other spices are balanced. For instance, when creating a fish curry, the hot oil is first filled with mustard seeds, then it is filled with cumin, coriander, fennel, and turmeric, then it is filled with garlic and ginger, and last it is filled with onions. To avoid bitterness, saffron is added towards the end after the oil separates, along with the tomatoes and previously dry-roasted fenugreek seeds. This results in the complex flavours of South Asian cuisine being layered in a balanced manner.

10.13. Global Equipment used in Spice Preparation

Various common tools are used to prepare spices in numerous civilizations all over the world. The standard domestic spice preparation instruments are mortar and pestles, woks, and kwalis. Black peppercorns, as well as other spices, are historically blended coarsely for use in sauces and condiments by using mortars and pestles to crush, pound, and coarsely grind whole dry spices, chile peppers, or garlic. (The impact of spice preparation and cooking methods on flavours is covered in more detail in the section in Chapter 6, "Emerging Flavour Contributors.")

In many various cultures, mortars and pestles go by different names. In Mexico, they are called molcajete and tejolate; in Thailand, krok and saak; in Malaysia, batu lesung; in Tamil, idi kallu; in Hindi; in Amharic, wurk kacha; and in Tagalog, almirez. They can be formed of granite, marble, wood, baked clay, volcanic or lava rock, stone, ceramic, stone, or stone. They exist in various sizes and are crucial appliances in kitchens in Southeast Asia, India, and Mexico. A coffee grinder or spice mill can accomplish the same task in the US.

The rectangular, flat stone known as metate in Mexican, batu giling in Malaysia, ammi in Tamil, or chakki in Hindu is another instrument used in the preparation of spices. These are employed to finely grind spices, including sesame seeds, chilli peppers, onions, and garlic. To transform ground spice into a paste, water is added during the grinding process. Because of this, certain metates include a gentle downward slope that enables the paste to be massaged into a container that is positioned beneath the front border. As a grinding tool, the stone rolling pin, or metlapil, is employed. These are the equipment that Mexicans use to grind roasted chilli peppers, chocolate and maize. Asian Indians crush rice that has been soaked, lentils, chilli peppers, onions, ginger, and garlic. Currently, a spice mill, blender, orMade of iron, brass, aluminium, or cast iron, the wok-kwali (Malaysian), tsao-guo (Mandarin), or kadai/karhai (Hindi/Urdu) is used to dry roast whole spices and saute whole spices or crushed spices in oil.

Spices, tomatoes, garlic, corn and chiles are all roasted on the flat griddle, also known as a comal in Mexican or a tawa in Hindi. Slaked lime is applied to the clay-type comal in Mexico to prevent food from clinging to it and causing hot spots in the spice that is being roasted.

The wok-*kwali* (Malaysian), *tsao-guo* (Mandarin), or *kadai/karhai* (Hindi/Urdu) is made of iron, brass, aluminum, or cast iron and can be used to dry roast whole spices and saute whole spices or ground spices in oil.

10.14. Spice Applications

Spices give meals and drinks savoury, spicy, sweet, pungent, bitter, or sour flavours. Spices and other flavourings can be combined to produce a wide range of flavours and fragrances. Chinese utilise them to contrast sweet, sour, or pungent tones with vivid textures, while Asian Indians employ them to produce distinctively balanced curry blends. Caribbeans, Japanese, and Thais use spices to great visual effect. Spices are the main component of flavour, texture, and aesthetic appeal in final items, whether we are constructing authentic or fusion themes or simply adding ethnic flair to classic American cuisine.

10.15. Marinades, Rubs, and Glazes

Unique seasonings offered through marinades, rubs, glazes, or as sprinkle-on seasonings are emerging as the hottest new trends in the food industry as consumers continue to demand great, healthful foods that are simple to make. Through the use of simple-to-prepare or ready-to-eat items, these marinades and dry seasonings can enhance convenience for consumers while generating a range of flavours and textures.

The ideal combinations of dried spices or extractives can be used to create dry rubs, emulsions, topical seasonings, glazes, and tumbling or injection marinades for food. These ingredients should be balanced with acids, salt, sugar, starch, and starch.

Rubs and glazes provide a product flavour and texture. To impart flavour to chicken, pork, or shellfish, rubs in dry or paste form that comprise a marinade of flour, sugar, salt, and vinegar can be used. These have visually appealing spice particles in them. For instance, the distinctive crispy coats on blackened chicken or fish, two classic Cajun meals, come from spice rubs. When employing spice marinades that include high tomato solids or high D.E. (dextrose equivalent) maltodextrins, undesirable, burnt flavours frequently occur. Therefore, for preserving flavours in processed meals, encapsulated spices are chosen.

Starch, gums, and spices are all ingredients in dry or liquid glazes, which may or may not also contain spice particles. Some glazes persist on surfaces to add aesthetic and textural appeal while also penetrating the product to impart flavour. Glazes are applied on meats in tumblers after the marinades in the processed meat business have been absorbed by the meat.

The oldest marinades were made by combining salt, spices, and vinegar with fruit juices to flavour and preserve meats. Today's marinades often include oil, vinegar or other acid sources, salt, sugar, alkaline phosphates, coarsely or finely crushed spices (with or without particulates), and oil. One of two types of marinades are tumbling and injection. A tumbling marinade involves placing the meat in a tumbler and adding the marinade. When the product has absorbed the marinade, the meat pieces are turned under vacuum. With no particles or insoluble spices, injection marinade is an internal soluble spice extractive. A entire bird or meat, such as rotisserie chicken, is injected with the spice solution to give flavour, resulting in a consistent flavour and colour.Use colourless spice alternatives, such as decolorized capsicums, black pepper, or turmeric, to prevent colour streaks on items. This injection is occasionally followed by a tumble step.

10.16. Spice Blends, Seasonings, and Condiments

The spice mixtures in aromatic vindaloos, tart colombos, peppery sambals, and smoky tagines give them their distinctive flavours. This is covered in great length in Chapter 7, "Emerging Spice Blends and Seasonings." It's crucial to keep in mind the wide range of spice blends that are available while making or using ethnic spice blends. There are flavour differences even for specific spice blends like adobos, curry mixes, ras-el-hanout, or recados based on regional and cultural preferences and component availability.

Table 14 Global Curry Blends and Their Characterizing Flavorings

Global Region	Flavor	Characterizing Ingredients
India		
Basic curry blend	Mild, medium, or hot, aromatic	Turmeric, cumin, coriander, ground cayenne or black pepper
North India	Creamy, mild, nutty	Yogurt, almonds, bay leaf, mint, clove, cinnamon, cardamom, garlic, onions, paprika
South India	Hot, fiery, coconutty	Coconut, tamarind, fresh green chile pepper, fennel seed, dried red chile pepper, turmeric, mustard seeds, kari leaf, ginger
East India	Sweet, medium hot, aromatic	Mustard, tamarind, kalonji, fenu, Greek seed, coriander leaf
West India	Hot, sour	Vinegar, cayenne pepper, mint, Saffron, coriander leaf

Sri Lanka	Black, fiery	Coconut milk, toasted spices, cayenne pepper
Pakistan	Mild, creamy, nutty	Paprika, bay leaf
Southeast Asia	Aromatic, hot, pungent, coconutty	Coconut, star anise, lemongrass, coriander leaf, turmeric, galangal, cayenne, mint, ginger, tomato fish sauce, shrimp paste, kari leaf, peanuts
East Asia	Mild, sweet, starchy	Soy sauce, turmeric, corn starch, caramel, fish sauce, sugar
Caribbean	Slightly sour, hot, fruity	Habaneros, allspice, turmeric, vinegar, black pepper, fruits, onions
England	Sweet, fruity	Apples, raisins, cream, turmeric, sugar
Middle East	Spicy, nutty, intense	Black pepper, caraway, tomato, mint, olive, sumac, pistachio, sesame seed, nigella
South Africa	Mild, sweet, fruity	Turmeric, clove, mace, cinnamon, nutmeg, bay leaf

For instance, no two curry blends, spaghetti sauces, salsas, or chilli blends are exactly alike. Even within a same location, curry blends can differ (Table 14). Curry (or spice blends for sauces) began in India and spread to other regions of the world, where local preferences led to ingredient substitutions and additions. Because of the ingredients they contain, curry blends from India, Thailand, Japan, the Caribbean, England, and Africa differ substantially from one another. Even in India, the flavour of a curry blend varies based on where it is made, who creates it, and whether it is used for lamb, fish, or lentils. Most curry mixtures contain a few of the

10.17. CONCLUSION

It is vital to have knowledge of commercial crops, spices, and aromatic and medicinal plants. There are plenty of job opportunities there. Since ancient times, India has been renowned for its expertise in their cultivation and superior processing. Indians were sent abroad to provide knowledge about growing various spices. Many centuries ago, traders sold Indian spices. Because they have no adverse effects, traditional herbal remedies are suitable for human bodies. In addition to acting as antioxidants, spices also strengthen the body's immune system. Every crop has a different method of production and processing. The extraction of the active component will determine the process technology.

PROGRESS EXERCISE

1. Define the composition of various spices.
   ………
2. What are various fresh spices which is used in daily meal.
   ……….
3. Write down the uses of dried spices.
   ……..
4. Define volatile oils in spices
   ……..
5. Define storage Conditions with Spices
   ……….
6. Write down the function of spices.
   …….
7. Define the role of spices as antimicrobial.
   ……
8. Define the role of spices as antioxidents.
   ……..

9. Define the role of spices as various traditional medicine
………………………………………………………………………………
………………………………………………
10. Use of spices in modern medicine.
………………………………………………………………………………
………………………………………………..
11. Write spice preparation technique.
………………………………………………………………………………
…………………………………………………
12. Define spice application in various process.
………………………………………………………………………………
………………………………………………………

KEY WORDS

Essential oils : It is a complex mixture of odours and steamvolatile compounds, which are deposited by plants in the sub-cuticular space of glandular hairs, in cell organelles or in canals of woods.

Comminution : It is the process of size reduction of any substances so that surface area is increased.

Steam distillation : It is the process of boiling the substances with water, so that water soluble volatiles oils are carried away by the steam. Then steam is to be condensed so that oils being lighter can be easily separated.

Rancidity : Off flavour of fat caused by oxidation.

Seasoning : Ground spice.

Shelf Life : Storage period of product.

Water Holding Capacity : Holding of water molecules by protein.

REFERENCES

Anonymous (2003) Post Harvest Technology of Chilli, Pepper, Cardamom Pubilaction No 6,7, 8 /2003 TNAU, Coimbatore.

Atal, C.K. and Kapur, B.M. (1982) Cultivation and Utilization of Aromatic Plants CSIR, Jammu Tawi.

Babu, C.K., Kumar, M.V. and Rangana, B. (1999) Post Harvest Management of Tamarind Published by PHTS, UAS, Bangalore.

Babu, C.K., Rangana, B. and Kumar, M.V. (1999) Status Report on Processing of Pepper Published by PHTS, UAS, Bangalore.

Chomchalow, Narong and Henle, H.V. (1995) Medicinal and Aromatic Plants in Asia. Oxford and IBH Publishing N. Delhi.

Prajapati, N.D., Purohit, S.S., Sharma, A.K. and Kumar, Tarun (2003) A Hand Book of Medicinal Plants.

Agrobios (India) Agro House, Jodhpur. 7. Purthi, J.S. (1993) Major Spices of India. Published by ICAR, New Delhi.

Tata, S.N. and Wadhwani, A.M. (1992) Hand Book of Agriculture Published by ICAR, New Delhi.

Unit: XI. FERMENTATION TECHNOLOGY

STRUCTURE:

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11.1. Microbial Growth
11.2. **Fermentation Process**
11.3. Fermentation Techniques
11.4. Application of Fermentation Technology

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11.5.3. Solid State Fermentation

11.5.4. Fermented Vegetables

11.6. Sauerkraut.
11.7. Cucumbers (pickling)

11.8. Fermented Foods From Cereals and Beans

11.8.1. Idli

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11.8.4. Raw materials for brewing

a) Brewer's yeasts

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1. Malting
2. Cleaning and milling of the malt
3. Mashing
4. Mash operation
5. Wort boiling treatment
6. Fermentation
7. Storage or lagering

OBJECTIVES

After reading this Unit, we shall be able to:

- Describe beneficial role of microorganisms;
- Explain fermentation – its science and technology;
- Comprehend the needs and types of food fermentations;
- State common examples of different types of food fermentations; an

11. FERMENTATION TECHNOLOGY

11.0. Introduction

Fermentation word is derived from Latin verb "fervere" which means to boil. This technology has been perceived in different sense by the world of microbiologist and biochemist. For biochemists, "fermentation is a catabolic process leading to generation of energy". Whereas, according to industrial microbiologist, "fermentation is the process of mass cultivation of micro-organisms that convert substrates into valuable products through aerobic or anaerobic route". A general outline of the process is outlined in figure 1. Fermentation technology has wide application for the production of products such as organic solvents (acetone, alcohols), fermented beverages (wine, beer, whisky), and other products like enzymes, amino acids, vitamins, pharmaceuticals etc. The fermentation processes is dependent on microbial growth, which in turn is governed by many biochemical and physical parameters. The motive of all parameters is to provide the most suitable environment for the growth of micro-organisms. This chapter is dedicated to discuss the growth characteristics of micro-organisms, the types and needs of fermentation process and their applications.

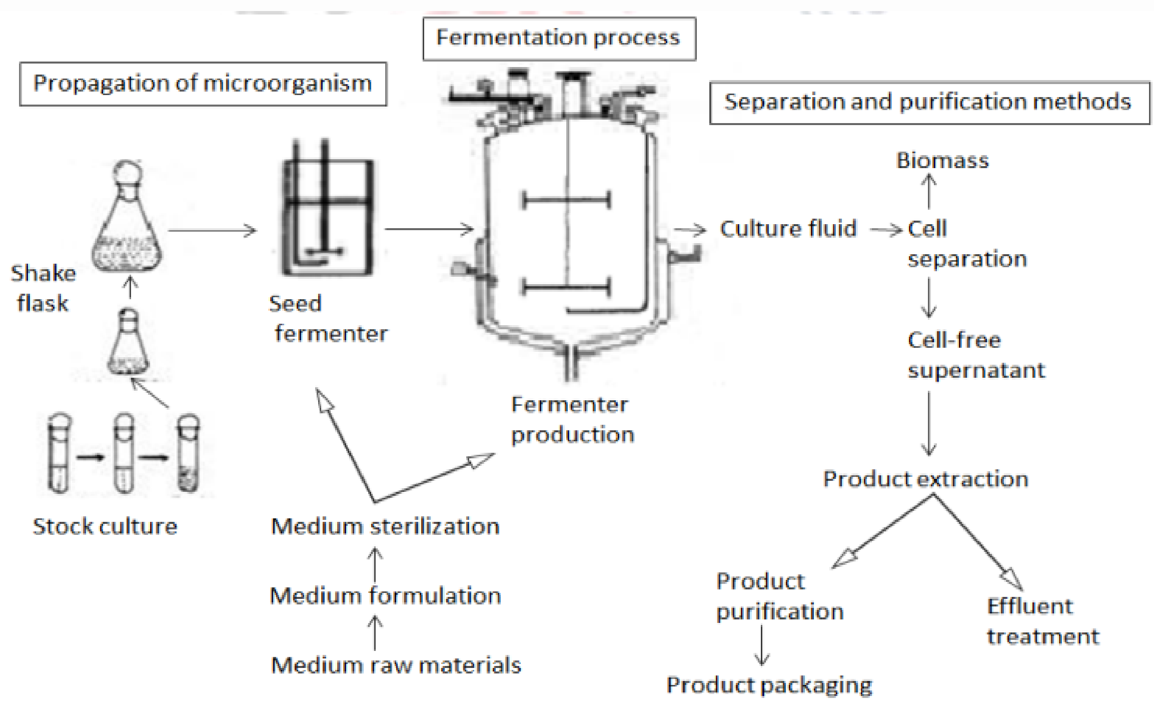

Figure 1: Outlines of Fermentation Technology

Figure 1: Outlines of Fermentation Technology 1.1

11.1. Microbial Growth The most important criterion of a fermentation process is to achieve good yield of product which in turn is dependent on the proper microbial growth. The micro-organism require optimum pH, temperature, oxygen, minerals, energy source and other raw material conditions to complete their life cycle under six phases as illustrated in figure 2 and discussed below.

a) Lag phase is the no microbial growth phase, also known as acclimatization period, when the newly inoculated micro-organism adapt to their new environment and hence show no increase in number.

b) Acceleration phase: is the period when microbes start increasing in number

c) Log phase: is the period when microbes demonstrated exponential increase in their number and utilizes most of the raw materials for their growth.

d) Stationary phase is the static stage when microbes does not show any change in their number and their growth arrest at this point, probably due to the depletion of energy sources in the media, constraints of space and accumulation of toxic end products.

e) Death phase is the time where microbes show steady decline in their number due to loss of ability to reproduce and indicate the climax of their growth period.

All these phases of microbial life illustrate a sigmoidal curve, and depending upon the type of product particular phase is considered for their harvest. For example, the processes where cell biomass is required, microbes are harvested after exponential growth. Whereas, when secondary metabolites are the major products, harvest is done after their production in stationary phase.

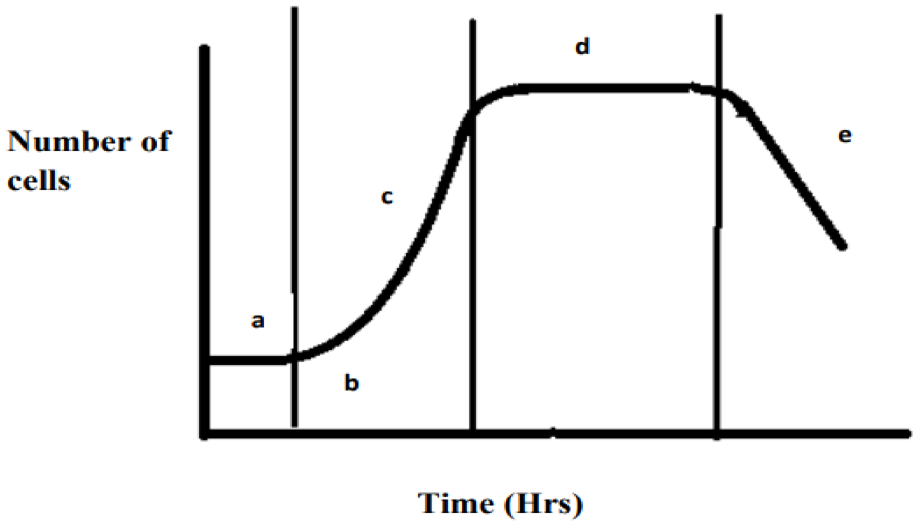

Figure 2: Growth phases of micro-organisms

The figure depicts the microbial growth in a batch fermentation system where one time addition of microbial culture and sterilized media components is done. It is a closed system, where no further addition or removal of materials are followed until the all the stages of microbial life cycle are completed and product is formed. After completion, the product is removed and processed under various downstream processes. Another type of fermentation process is fed-batch, where nutrients are fed more than one times during microbial cultivation, but products are harvested only at the end of the process. This method provides opportunity to control the yield and productivity of the process by adding limiting nutrients at defined phase of cell growth. For example the substrates such as ethanol, methanol or acetic acid may be added at the later stages of cell growth to avoid their inhibitory effect at initial growth phase. The most valuable method for high turnover of industrial products is the continuous fermentation that allows continuous supply of nutrients and raw materials. To maintain a static environment inside the vessel, products are also harvested continuously from the overflow of fermenter. The exponential growth of microbes is maintained for a prolonged period which is suitable for production of primary metabolites such as organic acids, amino acids, single cell protein etc. Time (Hrs) Number of cells a c d e b Figure 2: Growth phases of micro-organisms Environmental Sciences

11.2. **Fermentation Process**

Initially, Louis Pasteur described fermentation as “an anaerobic process carried out by yeast like organism to break complex sugars in simpler ones”. But, now fermentation includes anaerobic as well as aerobic processes that need maintenance of oxygen deficient or supplemented aseptic conditions. In case of anaerobic fermentation, no aeration device is needed as the gases generated during the process enable satisfactory mixing.

The environment inside the vessel needs to be maintained oxygen scarce during the whole process which is maintained by flushing a mixture of CO2, H2 and N2 in the head space of the fermenter. On the other hand, large volumes of oxygen approximately 60 times the medium volume are required for aerobic fermentation processes. Such fermenters need provision of efficient aeration and uniform mixing of fermenter contents. To accomplish sterilized conditions along with uniform distribution of media, air, pressure and timely escape of products, a special vessel known as Fermenter is employed. In addition to above mentioned conditions, a fermenter should facilitate the following functions:

1. A fermenter should meet the requirement of containment that means to prevent the escape of viable cells during fermenter process or downstream processing.
2. It should provide continuous online monitoring of undergoing process through pH, temperature and pressure sensors.
3. A fermenter should provide stable environment required for the process with minimum consumption of operating power, maintenance labour, construction cost etc.
4. A pilot scale fermenter should provide the opportunity of scaling up the process.

A typical bioreactor has the following parts with specified functions as illustrated in figure 3. Principles of chemical engineering are applied to design a fermenter.

a**. Agitator** is used for uniform mixing of media constituents and to keep the cells suspension homogenous. Agitation also approves air dispersion, and random transfer of oxygen and heat. The most important function of an agitator is to reduce shear forces and forming produced during the biochemical conversion. To achieve homogenous environment through the vessel, different types of stirrer or impellers such as disc turbine, vaned disc, open turbine and propeller are used. All these agitators are designed to achieve objectives of gas-phase and bulk fluid mixing.

b. **Aeration System** plays the crucial role along with agitators to supply sufficient oxygen to growing cells without causing any damage to them. The device used for this purpose is known as sparger.

Sparger is needed for efficient aeration by bubbling of air through the medium, as surface aeration is inefficient for submerged cultures. The kind of aeration system required in a fermenter is characterized by the type of process and attributes of media constituents and microbial culture. Sometimes only aeration could achieve the functions of proper mixing and oxygen supply which eliminated the need of extra agitator. Such conditions are dictated by the less viscous broth, and bacterial cultures. For high viscosity broths, it is desired that Fermenters with height/diameter ration of 5:1 provide uniform mixing by aeration system only and save equipment and power cost. But, for fungal cultures proper mixing by agitators is required.

c**. Baffles** are the metal strips attached radially to the vessel wall to prevent whirl formation and to perform efficient aeration. Their length may be one tenth of the vessel diameter with diameter less than 3 meters and their number varies from 4 to 8. Wider baffles are advised to have positive effect on agitation efficiency as compared to narrow baffles. A gap between the baffles and fermenter wall prevent microbial growth at the vessel wall Specially designed fermenters are employed for specific product production which depends on the process kinetics, the kind of raw materials used and magnitude of process parameters required during the process.

11.3. Fermentation Techniques

- Solid State Fermentation
- Submerged Fermentation

Microorganisms are cultivated on the surface of a liquid or solid substrate. Microorganisms grow in a liquid medium. Complicated and rarely used in industry. Simple and used in routine. Used in Production of Mushroom, Bread, Cocoa and temph etc. Protein, Biomass, antibiotics, enzymes and sewage treatment are carried out by submerged fermentation.

11.4. Application of Fermentation Technology

Advances in fermenter designing and fermentation technology have led to the additives are manufactured using industrial fermentation technology in developing countries. Wild type and recombinant microorganisms are used in the production of following products.

1. Alcoholic beverages	Whisky, rum, brandy, Beer and wine
2. Milk and Milk Products	Cultured milks, yoghurt, cheese
3. Microbial flavors	Vanillin, benzaldehyde and lactones
4. Biofuels	Ethanol, acetone-butanol
5. Microbial polysaccharides	Dextran, xanthan gum and pullulan
6. Food additives and ingredients	L-glutamic acid and L-aspartic acid
7. Vitamins	Vitamin A, C, B12, and riboflavin
8. Enzyme	Amylase, invertase, Protease
9. Organic acid	Lactic acid, citric acid, acetic acid

The end product of a fermentation process depends upon the kind of microbe used for the process. Many bacteria, protists, fungi and animal cells produce lactic acid, water and carbon dioxide, whereas yeast and plant cells yield alcohol, water and carbon dioxide. Thus, most of the alcoholic beverages are produced by the action of yeast on carbon sources such as malted barley, millet, sorghum, cassava etc. Among all the fermented alcoholic beverages, beer making (brewing) is the oldest and the most researched process.

11.5. TYPES OF FOOD FERMENTATIONS

A number of different types of food fermentation can be recognized

11.5.1.Acid Food Fermentation

These include acid fermented dairy products, e.g. cheese, butter, yoghurt and kefir; acid fermented vegetable products, e.g. sauerkraut, olives and various pickles; acid fermented meat products, e.g. the semi-dry fermented meats such as cerevelat and the dry fermented meats such as salami and pepperoni; sour dough breads. The common feature of all these products is the use of lactic acid bacteria to carry out the basic fermentation process. Modern production systems usually involves the use of starter cultures. An exception is the fermentation of sauerkraut for which the process depends on lactic acid bacteria, that are natural inhabitants of the surface of cabbage leaves. Sometimes sugar is added to raw material to allow the lactic acid bacteria to produce sufficient acid for a successful fermentation. This is the case with fermented meats in which the sugar content of the raw material is very low. Salt may be added to suppress the growth of the normal spoilage micro flora and allow the lactic acid bacteria to dominate, e.g. sauerkraut, pickles and fermented meats. The raw materials may be pasteurized to eliminate pathogens and suppress natural contaminants that compete with the lactic acid bacteria, used in the starter culture

11.5.2. Yeast Fermentation

Yeasts are important in food fermentation because of their ability to produce carbon dioxide and ethanol. Carbon dioxide is the important metabolic product in the manufacture of leavened bread whereas ethanol is metabolized in the production of beer, wine and spirits

11.5.3. Solid State Fermentation

Solid state fermentation involves the use of a solid substrate into which the fermenting organism is inoculated. The organisms used are often molds. Examples are the 'koji' process and the second stage of tempeh fermentation

11.5.4. Fermented Vegetables

Like the fermentation of other foods, vegetables have been preserved by fermentation from time immemorial by lactic bacterial action. A wide range of vegetables and fruits including cabbages, olives, cucumber, onions, peppers, green tomatoes, carrots, okra, celery, and cauliflower have been preserved. Only sauerkraut and cucumbers will be discussed, as the same general principles apply to the fermentation of all vegetables and fruits. In general they are fermented in brine, which eliminates other organisms and encourages the lactic acid bacteria.

11.6. Sauerkraut. Sauerkraut is produced by the fermentation of cabbages, *Brassica oleracea*, and has been known for a long time. Specially selected varieties which are mild-flavored are used. The cabbage is sliced into thin pieces known as slaw and preserved in salt water or brine containing about 2.5% salt. The slaw must be completely immersed in brine to prevent it from darkening. Kraut fermentation is initiated by *Leuconostoc mesenteroides*, a heterofermentative lactic acid bacterium (i.e., it produces lactic acid as well as acetic acid and CO_2). It grows over a wide range of pH and temperature conditions. CO_2 creates anaerobic conditions and eliminates organisms which might produce enzymes which can cause the softening of the slaw and also encourages the growth of other lactic acid bacteria. Gram negative coliforms and pseudomonads soon disappear, and give way to a rapid proliferation of other lactic acid bacteria, including *Lactobacillus brevis*, which is heterofermentative, and the homofermentative *Lactobacillus plantarum*; sometimes *Pediococcus cerevisiae* also occurs. Compounds which contribute to the flavor of sauerkraut begin to appear with the increasing growth of the lactics. These compounds include lactic and acetic acids, ethanol, and volatile compounds such as diacetyl, acetaldehyde, acetal, isoamyl alcohol, n-hexanol, ethyl lactate, ethyl butarate, and isoamyl acetate. Besides the 2.5% salt, it is important that a temperature of about 15°C be used. Higher temperatures cause a deterioration of the kraut.

11.7. Cucumbers (pickling)

Cucumber (*Cucumis sativus*) is eaten raw as well after fermentation or pickling. Cucumbers for pickling are best harvested before they are mature. Mature cucumbers are too large, ripen easily and are full of mature seeds. Cucumbers may be pickled by dry salting or by brine salting .

Dry salting is also generally used for cauliflower, peppers, okra, and carrots. It consists of adding 10 to 12% salt to the water before the cucumbers are placed in the tank. This prevents bruising or other damage to the vegetables.

Brine salting is more widely used. A lower amount of salt is added, between 5 and 8% salt being used. Higher amounts were previously used to prevent spoilage. During the primary fermentation lasting two or three days, most of the unwanted bacteria disappear allowing the lactics and yeasts to proliferate. In the final stages, after 10 to 14 days, *Lactobacillus plantarum* and *L. brevis*, followed by *Pediococcus*, are the major organisms.

11.8. Fermented Foods From Cereals and Beans

11.8.1. Idli

Idli is a popular fermented breakfast and hospital food which has been eaten in South India for many years. It is prepared from rice grains and the seeds of the leguminous mung grain, *Phaeseolus mungo*, or from black gram (*udad* dhal), *Vigna mungo*, which are also known as dal. When the material contains Bengal grain, *Circer orientium*, the product is known as khaman. It has a spongy texture and a pleasant sour taste due to the lactic acid in the food. It is often embellished with flavoring ingredients such as cashew nuts, pepper and ginger.

11.8.2. Production of idli

The seeds of the dahl (black gram) are soaked in water for 1-3 hours to soften them and to facilitate decortication, after which the seeds are mixed and pounded with rice in a proportion of three parts of the beans and one of rice (Figure 31.1). The mixture is allowed to ferment overnight (20-22 hours). In the traditional system the fermentation is spontaneous and the mixture is leavened up to approximately 2 or 3 times. The organisms involved in the acidification have been identified as *Streptococcus faecalis,* and *Pediococcus* spp. The leavening is brought about by *Leuconostoc mesenteroides*, although the yeasts, *Torulopsis candida* and *Trichosporon pulluloma* have also been found in traditional Idli. The fermented batter is steamed and served hot. Idli is highly nutritious, being rich in nicotinic acid, thiamine, riboflavin, and methionine.

11.8.3. **Production of beer**

Barley beers can be divided into two broad groups: top-fermented beers and bottom fermented beers. This distinction is based on whether the yeast remains at the top of brew (top-fermented beers) or sediments to the bottom (bottom-fermented beers) at the end of the fermentation.

11.8.4. Raw materials for brewing

The raw materials used in brewing are: barley, malt, adjuncts, yeasts, hops, and water.

a) Brewer's yeasts

Yeasts in general will produce alcohol from sugars under anaerobic conditions, but not all yeasts are necessarily suitable for brewing. Brewing yeasts besides producing alcohol, are able to produce from wort sugars and proteins in a balanced proportion of esters, acids, higher alcohols, and ketones which contribute to the peculiar flavor of beer.

b) Brewery Processes

The processes involved in the conversion of barley malt to beer may be divided into the following:

1. Malting
2. Cleaning and milling of the malt

3. Mashing
4. Mash operation
5. Wort boiling treatment
6. Fermentation
7. Storage or lagering
8. Packaging

11.9. Malting

The purpose of malting is to develop amylases and proteases in the grain. These enzymes are produced by the germinated barley to enable it to break down the carbohydrates and proteins in the grain to nourish the germinated seedling before its photosynthetic systems are developed enough to support the plant.

a. Cleaning and milling of malt

The purpose of milling is to expose particles of the malt to the hydrolytic effects of malt enzymes during the mashing process. The finer the particles, greater the extract from the malt.

b. Mashing

Mashing is the central part of brewing. It determines the nature of the wort, hence the nature of the nutrients available to the yeasts and therefore the type of beer produced. The purpose of mashing is to extract as much as possible the soluble portion of the malt and to enzymatically hydrolyze insoluble portions of the malt and adjuncts. The aqueous solution resulting from mashing is known as wort. The wort is boiled for 1-1½ hours in a stainless steel kettle. When corn syrup or sucrose is used as an adjunct it is added at the beginning of the boiling. Hops are also added, some before and some at the end of the boiling. Hops are the dried cone-shaped female flower of hop-plant *Humulus lupulus*. The importance of hops in brewing lies in its resins which provide the precursors of the bitter principles in beer and the essential (volatile) oils which provide the hop aroma.

The purpose of boiling is as follows.

(a) To *concentrate* the wort,

(b) To *sterilize* the wort

(c) To *inactivate* any enzymes

(d) To *extract* soluble materials from the hops

(e) To precipitate protein, which forms large flocs because of heat denaturation and complexing with tannins extracted from the hops and malt husks. Unprecipitated proteins form hazes in the beer, but too little protein leads to poor foam head formation.

(f) To develop color in the beer; some of the color in beer comes from malting but the bulk develops during wort boiling. Color is formed by several chemical reactions including caramelization of sugars, oxidation of phenolic compounds, and reactions between amino acids and reducing sugars.

(g) Removal of volatile compounds: volatile compounds such as fatty acids which could lead to rancidity in the beer are removed.

c. Fermentation

The cooled wort is pumped or allowed to flow by gravity into fermentation tanks and yeast is inoculated or 'pitched in' at a rate of 7-15 x 10^6 yeast cells/ml, usually collected from a previous brew. The progress of fermentation is followed by wort specific gravity. During fermentation the gravity of the wort gradually decreases because yeasts are using up the extract. However, alcohol is also being formed. As alcohol has a lower gravity than wort the reading of the special hydrometer (known as a saccharometer) is even lower. °Brix is used in the sugar industry, whereas Balling (United States) and °Plato (continental Europe) are used in the brewing industry.

d. Lagering

During lagering secondary fermentation occurs. Yeasts are sometimes added to induce this secondary fermentation, utilizing some sugars in the green beer. The secondary fermentation saturates the beer with CO_2.

e.Packaging

The beer is transferred to pressure tanks from where it is distributed to cans, bottles and other containers. The beer is not allowed to come in contact with oxygen during this operation; it is also not allowed to lose CO_2 or to become contaminated with microorganisms. To achieve these objectives, the beer is added to the tanks under a CO_2, atmosphere, bottled under a counter pressure of CO_2 and all the equipment is cleaned and disinfected regularly.

11.10.Beer defects

The most important beer defect is the presence of haze or turbidity, which can be of biological or physico-chemical origin. Biological turbidities are caused by spoilage organisms and arise because of poor brewery hygiene (i.e. poorly washed pipes) and poor pasteurization. Spoilage organisms in beer must be able to survive the following stringent conditions found in beer: low pH, the antiseptic substances in hops, pasteurization of beer, and anaerobic conditions.

Yeasts and certain bacteria are responsible for biological spoilage because they can withstand these. Wild or unwanted yeasts which have been identified in beer spoilage are spread into many genera including *Kloeckera*, *Hansenula,* and *Brettanomyces,* but *Saccharomyces* spp appear to be commonest, particularly in top-fermented beers. These include *Sacch. cerevisiae* var. *turblidans,* and *Sacch. diastaticus.* The latter is important because of its ability to grow on dextrins in beer, thereby causing hazes and off flavors. Among the bacteria, *Acetobacter,* and the lactic acid bacteria, *Lactobacillus* and *Streptococcus* are the most important. The latter are tolerant of low pH and hop antiseptics and are microaerophilic hence they grow well in beer. *Acetobacter* is an acetic acid bacterium and produces acetic acid from alcohol thereby giving rise to sourness in beer. *Lactobacillus pastorianus* is the typical beer spoiling lactobacilli, in top-fermented beers, where it produces sourness and a silky type of turbidity. *Streptococcus damnosus* (*Pediococcus damnosus*, *Pediococcus cerevisiae*) is known as ‘beer sarcina’ and gives rise to ‘sarcina sickness’ of beer which is characterized by a honey-like odor.

11.11. Wines

Wine is by common usage defined as a product of the “normal alcoholic fermentation of the juice of sound ripe grapes”. Nevertheless any fruit with a good proportion of sugar may be used for wine production. If the term is not qualified then it is regarded as being derived from grapes, *Vitis vinifera*. The production of wine is simpler than that of beer in that no need exists for malting since sugars are already present in the fruit juice being used. This however exposes wine making to greater contamination hazards

11.11.1. Processes in wine making

a. Crushing of grapes

Selected ripe grapes are crushed to release the juice which is known as 'must', after the stalks which support the fruits have been removed. These stalks contain tannins which would give the wine a harsh taste if left in the must. The skin contains most of the materials which give wine its aroma and color. Grape juice has an acidity of 0.60-0.65% and a pH of 3.0-4.0 due mainly to malic and tartaric acids with a little citric acid.

b. Fermentation

(i) **Yeast used:** The grapes themselves harbor a natural flora of microorganisms (the bloom) which in previous times brought about the fermentation and contributed to the special characters of various wines. Yeasts are then inoculated into the must. The yeast which is used is *Saccaromyces cerevisiae* var, *ellipsoideus* (synonyms: *Sacch. cerevisiae, Sacch. ellipsoideus, Sacch, vini.).*

Wine yeasts have the following characteristics: (a) growth at the relatively high acidity (i.e., low pH) of grape juice; (b) resistance to high alcohol content (higher than 10%); (c) resistance to sulfite.

c. Control of fermentation

(a) **Temperature:** Heat is released during the fermentations. It has been calculated the temperature of a must containing 22% sugar would rise 52°F (11°C) if all the heat were stopped from escaping. If the initial temperature were 60°F (16°C) the temperature would be 100°F (38°C) and fermentation would halt while only 5% alcohol has been accumulated. For this reason the fermentation is cooled and the temperature is maintained at around 24°C with cooling coils mounted in the fermentor.

(b) **Yeast nutrition:** Yeasts normally ferment the glucose preferentially although some yeasts e.g. *Sacch. elegans* prefer fructose. Most nutrients including macro- and micro-nutrients are usually abundant in must;

occasionally, however, nitrogeneous compounds are limiting. They are then made adequate with small amounts of $(NH_4)_2 SO_4$.

(c) **Oxygen:** As with beer, oxygen is required in the earlier stage of fermentation when yeast multiplication is occurring. In the second stage when alcohol is produced the growth is anaerobic and this forces the yeasts to utilize such intermediate products as acetaldehydes as hydrogen acceptors and hence encourage alcohol production.

(d) **Flavor development:** Although some flavor materials come from the grape most of it come from yeast action and has been shown to be due to alcohols, esters, fatty acids, and carbonyl compounds, the esters being the most important. Diacetyl, acetoin, fuel oils, volatile esters, and hydrogen sulfide have received special attention.

d. Ageing and Storage

The fermentation is usually over in three to five days. At this time 'pomace' formed from grape skins (in red wines) will have risen to the top of the brew. At the end of this fermentation the wine is allowed to flow through a perforated bottom if pomace had been allowed. When the pomace has been separated from wine and the fermentation is complete or stopped, the next stage is 'racking'. The wine is allowed to stand until a major portion of the yeast cells and other fine suspended materials have collected at the bottom of the container as sediment or 'lees'. It is then 'racked', during which process the clear wine is carefully pumped. The wine is then transferred to wooden casks (100-1,000 gallons), barrels (about 50 gallons) or tanks (several thousand gallons). The wood allows the wine only slow access to oxygen. Water and ethanol evaporate slowly leading to air pockets which permit the growth of aerobic wine spoilers e.g. acetic acid bacteria and some yeasts. The casks are, therefore regularly topped up to prevent the pockets. In modern tanks made of stainless steel the problem of air pockets is tackled by filling the airspace with an inert gas such as carbon dioxide or nitrogen. During ageing desirable changes occur in the wine. These changes are due to a number of factors:

e. Clarification

The wine is allowed to age in a period ranging from two years to five years, depending on the type of wine. At the end of the period some will have cleared naturally. For others artificial clarification may be necessary. The addition of a fining agent is often practiced to help clarification. Fining agents react with the tannin, acid, protein or with some added substance to give heavy quick-settling coagulums. The usual fining agents for wine are gelatin, casein, tannin, egg albumin, and bentonite.

f. Packaging

Before packing in bottles the wine from various sources is sometimes blended and then pasteurized. In some wineries, the wine is not pasteurized, rather it is sterilized by filtration. In many countries the wine is packaged and distributed in casks.

g. Wine defects

The most important cause of wine spoilage is microbial; less important defects are acidity and cloudiness. Factors which influence spoilage by bacteria and yeasts include the following (a) wine composition, specifically the sugar, alcohol, and sulfur dioxide content; (b) storage conditions e.g. high temperature and the amount of air space in the container; (c) the extent of the initial contamination by microorganism during the bottling process. When proper hygiene is practiced bacterial spoilage is rare. When it does occur the microorganisms concerned are acetic acid bacteria which cause sourness in the wine. Lactic acid bacteria especially *Leuconostoc,* and sometimes *Lactobacillus* also spoil wines. Various spoilage yeasts may also grow in wine. The most prevalent is *Brettanomyces*, slow growing yeasts which grow in wine causing turbidities and off-flavors. Other wine spoilage yeasts are *Saccharomyces oviformis,* which may use up residual sugars in a sweet wine and *Saccharomyces bayanus* which may cause turbidity and sedimentation in dry wines with some residual sugar. *Pichia membanaefaciens* is an aerobic yeast which grows especially in young wines with sufficient oxygen. Other defects of wine include cloudiness and acidity.

11.12. Fermented Soyabean Products

a) Tempeh

In Indonesia, a soyabean preparation called tempeh is very well-liked. The mould Rhizopus oligosporus is the main constituent of this preparation. The boiling soybean seeds are mashed and stored in boxes or tubes made of wood or banana leaves. A fraction of the previous batch is added, and the mixture is injected with tempeh fungal spores. It is then fermented for about 20 hours at 32° C until there is a healthy-growing mycelium but little sporulation. After that, it is cut into slices and cooked to taste by roasting or frying. Although tempeh is thought to have a bland flavour, it is very healthy.

b) Soya sauce

A particularly well-liked Japanese dish that has gained widespread global acceptance is soy sauce. This is made by inoculating Aspergillus oryzae (A. Soyae) in a 2:1 mixture of roasted wheat and soaked and steamed soy beans. For 3 to 5 days, the mixture is incubated at a temperature between 25 and 300 C. It is then put through a number of processing processes utilising the yeast Saccharomyces rouxii and the bacteria Lactobacillus delbruckii. The finished product is filtered, pasteurised, and packaged for usage after three months. c) Miso It is a thick paste-like substance derived from fermented soy beans.

c). Miso

is quite salty and sour on its own, and it has a brownish colour. The bacteria, Pediococcus halophilus, and Streptococcus faecalis, along with the yeasts Saccharomyces rouxii and Torulopsis, are primarily responsible for the fermentation of miso. Despite the fact that miso is typically used Miso not only enhances Japanese-style miso soup recipes but also salad dressings, sauces and marinades, baked tofu, and vegetable meals.

11.13. Fermented Dairy Products

Since milk products—particularly cheese, butter, yoghurt, and curd—constitute the majority of the human diet, fermented dairy products are of significant importance. The list of dairy products that have undergone fermentation is as follows:

Table 4.2: Types of Fermented Dairy Products

Name	Country of origin	Milk types, conditions	Micro flora
Dahi (Dadhi)	India Persia	Balkans Milk (Cow/	L. lactis subsp. lactis, S.

		Buffalo)	salivarius subsp. thermophilus, L. delbrueckii subsp. bulgaricus, plantarum, lactose fermenting yeast, Mixed culture
Srikhand (chakka)	India	Milk (Cow/ Buffalo)	S. salivarious subsp.thermophilus, L. delbrueckii subsp. bulgaricus.
Lassi	India	Milk (Cow/ Buffalo)	S. salivarius subsp. thermophilus, L. delbrueckii subsp.bulgaricus.
Cultured butter milk	Scandinevian and European countries	Milk (Cow/ Buffalo)	L. lactis subsp. lactis, L. lactic subsp. diacetylactis, Leuconostoc dextranicum subsp. citrovorum
Acidophilus milk	Australia,	Cow's milk	L. acidophilus
Yoghurt (bio-ghurt)	Middle Asia	Cow's milk Goat's or mixed milk	S, salivarius subsp.thermophilus, L. delbrueckii subsp. bulgaricus, Micrococcus and other lactic acid, bacteria, cocci, yeasts, molds
Kefir	Caucasus	Sheep's, Cow's, goat's or mixed milk, fermentation in skin bag or in wooden barrels	L lactis subsp. lactis, Leuconostoc spp., L.delbrueckii subsp. caucassiucu, Saccharomyces kefir, Torula kefir, micrococci, spore forming bacilli
Kumiss	Asiatic Steppes	Mare's, camel's or ass's milk fermentation in skin bag	L. delbrueckii subsp. bulgaricus, Torula kumiss, Saccharomyces lactis, micrococci, spore forming bacilli lactis,

			micrococci, spore forming bacilli
Leben, Labneh	Lebanon Arab countries	Goat's or sheep's milk, Fermentation in skin bag/ earthenware	L. lactis subsp. lactis, S. salivarius subsp. thermophilus, L. delbrueckii subsp. bulgaricus, lactose fermenting yeasts

11.14. Vinegar

The French terms vin and aigre, which translate to "sour wine," are the root of the English word "vinegar," which is now used to describe a condiment made from diverse ingredients that contain sugar and starch and are then fermented to produce acetic acid. It is one of the many fermented foods that have been created and eaten by humans since the dawn of time. In the past, it was employed as a medicine, a preservative, a condiment, a cleaning agent for the home, and a beverage.

In addition to fruit acids, esters, and inorganic salts that differ according on the vinegar's place of origin, it also contains colour, flavour, and extracts. Acetic acid makes up the majority of vinegar's composition. Acetic acid must be at least 4% (w/v) in vinegar to be considered lawful.

11.14.1. Types and Composition of Vinegar

1. Synthetic vinegar: This kind of vinegar is made by mixing water and synthetic acetic acid together before adding caramel colouring.

2. Brewed vinegar: To manufacture brewed vinegar, practically anything that contains enough sugar to produce alcohol can be utilised. The ingredient from which the vinegar is formed usually gives it its descriptive name, for example, cider vinegar is created from apple juice, alegar from ale, malt vinegar from malted grains, spirit vinegar from alcohol, etc.

11.14.2. Vinegar Preparation

It involves two step fermentations as detailed below:

11.14.3. Alcoholic fermentation:

The first is alcoholic fermentation, mainly carried out by yeast Saccharomyces cerevisiae either by pure culture inoculation or by the natural process of fermentation. The process can be represented by a simplified equation:

$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5-OH + 55$ Kcal

Glucose Carbon dioxide Ethyl alcohol

Small amounts of glycerol, succinic acid, amyl alcohol, propyl alcohol, and other chemicals are also created in this fermentation in addition to ethyl alcohol, which is not the only result of the process. Anaerobic fermentation is occurring. Fermentation of acetic acid: Acetic acid fermentation is the second fermentation process. Acetic acid bacteria like Acetobacter aceti perform the oxidative fermentation. Due to the greater effectiveness of mixed cultures, pure cultures of acetic acid bacteria are not employed in the manufacturing of vinegar. The oxidation reaction is represented as follows:

$C_2H_5OH + O_2 \rightarrow CH_3COOH + H_2O + 116$ Kcal

Ethyl alcohol → Acetic acid

The optimum temperature of fermentation is 26o C which is achieved by the heat generated in the process.

11.14.4. Process of Vinegar Preparation

a. Slow process:

This procedure requires a lot of time and is frequently used in nations like India. The juice kept in the barrels is allowed to gently ferment into alcohol and acetic acid over time. A piece of cloth is placed over the barrel's bung hole to keep out dust and flies, and the barrel is then placed in a warm, humid environment. To make vinegar from juice, the entire acetous and alcoholic fermentation process takes roughly 5 to 6 months to complete. The main problems of this procedure include a poor output, frequently incomplete alcoholic fermentation, sluggish acetic fermentation, and vinegar of subpar quality.

b. Quick process:

Alcoholic liquid is in motion in a rapid procedure like the generator process, which is usually used to make vinegar from spirit (alcohol). Food for the vinegar bacteria is present in fruit or malt liquors, but to keep the vinegar bacteria active in generator methods that use alcohol denatured with vinegar or ethyl acetate, it must be supplemented with a mixture of organic and inorganic substances known as vinegar food. Dibasic ammonium phosphate, urea, peptones, yeast extract, glucose, malt, starch, dextrin, salts, and other ingredients have all been combined. For packing the generators, materials like pumice, vine branches, and grape stems are employed.Schiizenbach developed a mechanical system for the repeated application of the acidic liquid to the packing and pioneered the use of a vat rather than a cask for the acetification process.

c. **Generator:**

The used equipment is referred to as a "Upright Generator," which is essentially just a cylindrical tank that is available in various sizes and is often built of wood. Its interior is split into three sections:

i) **Upper section:** Alcoholic beverage is introduced here.

ii) **Large centre section:** In this area, liquid is allowed to drip across materials like charcoal, coke, maize cobs, beech wood shavings or other items that have a lot of surface area overall but aren't compacted into a mass.

iii) **Bottom part:** The vinegar collection is kept in this section. The process of acetification involves adding the alcoholic liquid at the top through an automatic feed trough or a sprinkler and drizzling it over shavings or other materials on which acetic acid bacteria have grown slimily. The bacteria convert the alcohol to acetic acid during this process, which is known as acetification. Air enters through the centre section's false bottom, warms up, and then exits through a ventilation above. The oxidation process generates a lot of heat, thus it's important to keep the temperature below 30° C. Typically, cooling coils, regulating the flow rate of alcohol, feeding air, and cooling are used. The process typically involves cooling the alcoholic liquid before it enters the generator or cooling the partially acetified liquid that is returned to the top from the bottom section of the tank for additional acetification. It also typically involves using cooling coils, adjusting the rate of alcoholic liquid, feeding air, and cooling the alcoholic liquid.

11.15. Lactic Acid Bacteria (LAB) and Fermented Foods

In addition to creating inhibitory compounds including organic acids, bacteriocin, and hydrogen peroxide that are hostile towards other microbes, lactic acid bacteria (LAB) are obligatory microorganisms that produce lactate from carbohydrates as the principal end product. The best-known fermented milk product (with fruit pulp) is yoghurt, which is recognised to be inhibitory to both pathogenic and spoilage-causing microbes.

Lactic acid bacteria are found in cultured milk and milk products, and they protect against malignancies of the stomach, colon, and other organs.

Traditional vegetable fermentations relied on the development of lactic acid bacteria that are found in nature to break down the vegetables' natural sugars into lactic acid, which enhances the veggies' flavour and shelf life. The development of controlled fermentation, however, is now being done using starter cultures.

It is known that various species of lactic acid bacteria are involved in the fermentation of vegetables. Vegetables naturally ferment because of lactic acid bacteria belonging to the genera Streptococcus, Leuconostoc, Pediococcus, and Lactobacillus. Important variables influencing lactic fermentation include acidity, pH, salt concentration, temperature, naturally occurring inhibitors, chemical additions, exposed brined surface to air and sunshine, amount of fermentable carbohydrates in the vegetables, and availability of nutrients in the brine.

11.15.1. Economically Important Fermentation Products

A variety of products are produced as a result of the growth of microorganisms or other cells. Every culture operation has one or a few specific goals in mind. To maintain the precise conditions required and recover the best levels of goods, the process must be closely and continuously monitored. Fermentation procedures therefore seek to achieve one or more of the following:

a) the growth of cells (biomass) like yeasts;

b) the extraction of metabolic products for use in the creation of fertiliser or for human and/or animal nutrition, such as amino acids, proteins (including enzymes), vitamins, and alcohol;

c) chemical alteration (through the use of elicitors or by biotransformation); and

d) creating items using recombinant DNA.

11.15.2. Microbial Biomass

Using such unicellular algae as species of Chlorella or Spirulina for human or animal food, or viable yeast cells required for the baking industry, which was once utilised as human feed, microbial biomass is commercially generated as single cell protein (SCP). Animal feed can be made out of bacterial biomass. For a similar purpose, Fusarium graminearum biomass is also produced.

B. Microbial Metabolites

i) Primary metabolites –

Organisms produce a multitude of substances during the log or exponential phase that are necessary for their growth, such as nucleotides, nucleic acids, amino acids, proteins, carbohydrates, lipids, etc., or by-products of energy-producing metabolism, such as ethanol, acetone, butanol, etc. The products are typically referred to as primary metabolites, and this phase is referred to as the tropphase. Table 4.3 provides examples of these products in the marketplace.

2. **Secondary metabolites**

The main metabolites are not the only products that an organism produces. Secondary metabolites are created during the idiophase, a stage of microbial growth, which is characterised by the production of compounds that are not immediately apparent as being involved in the metabolism of the organisms that make up the synthesising culture. In actuality, there is no straight-jacket situation around the differentiation between primary and secondary metabolites. From the intermediates and byproducts of secondary metabolism, several secondary metabolites are created. The Enterobacteriaceae are among those that do not engage in secondary metabolism. Table 4.4 provides examples of secondary metabolites.

3. **Production of Enzymes**

The commercial manufacturing of food and drinks requires the industrial manufacture of enzymes. Currently, enzymes (such as cellulase, protease, and lipase) are even added to washing powders. Enzymes are also utilised in industrial and clinical analysis. Animal, plant, or microbial cultures can all create enzymes. Through methods of genetic manipulation, even plant and animal enzymes can be generated through microbial fermentation. Although the majority of enzymes are made during the tropophase, some, such as the amylases made by Bacillus stearothermophilus, are made during the idiophase and are hence secondary metabolites. Table 4.5 lists a few examples of enzymes created during fermentation operations.

Examples of Commercially Produced Enzymes, Table 4.5

Organism	**Enzyme**
Aspergillus oryzae	Amylases
Aspergillus niger	Glucoamylase
Trichoderma reesii	Cellulase
Saccharomyces cerevisiae	Invertase
Kluyzveromyces fragilis	Lactase
Saccharomycopsis lipolytica	Lipase
Aspergillus species	Pectinases and protease

Bacillus species	Proteases
Mucor pusillus	Microbial rennet
Mucor meihei	Microbial rennet

11.15.3. Enrichment and Fortification technology,

Food fortification is the process of incorporating one or more dietary components into food. The process of adding nutrients to foods is described by a number of terminology, some of which are detailed below.

i) **Enrichment:** This phrase refers to a procedure whereby the level of one or more nutrients, which are already present in a food, is significantly enhanced by addition to make it more abundant in that nutrient.

ii) **Fortification:** Fortification, according to the WHO, is the process of adding nutrients to food or dietary items in order to raise the nutritional value of a group's, community's, or population's diet. The amount of nutrients supplied can be higher than what was in the original or similar food. Fortification's goal is to help a particular population's nutritional deficits. In order to increase a population's intake of a nutrient, fortification may also involve the addition of modest amounts of the nutrient.

iii) **Nutrification:**Adding vitamins and minerals to prepared and processed foods that are consumed as complete meals or as meal replacements, such as infant formula, instant breakfast foods, etc., is referred to by this general phrase.

iv) **Restoration:** The handling, shipping, processing, and storage of food results in the unavoidable loss of some nutrients. The replacement of nutrients lost during the aforementioned processes is referred to as restoration.

v) **Standardization:**The nutrient makeup of foods may vary naturally or according to the seasons. The act of adding nutrients to make up for the aforementioned differences and bring them to a set level is known as standardisation. It aids in fulfilling nutritional labelling standards.

vi) **Supplementation:**This phrase describes the process of adding nutrients to food that are either not ordinarily available or are present in extremely little amounts.

The phrases mentioned above are frequently used in tandem. The term "fortification" is currently used to refer generally to the addition of nutrients to enhance the nutritional value of foods.

11.16. CONCLUSION

This unit has content of fermentation technology of food products. Various fermented products.Their processing and preparation technology.

Fermentation is a low-energy, moderately efficient food preservation method that lengthens the shelf life of food and eliminates the need for refrigeration or other food preservation methods. As a result, it is a technique that is ideal for usage in underdeveloped nations and distant locations without easy access to complex machinery. Worldwide, people like eating fermented foods, and in some places, millions of people rely heavily on them to supplement their diets. Fermenting food is a widely practised tradition in Asia. In contrast to starchy and bland meals, the fermented goods bring diversity and nutritional fortification by supplying protein, minerals, and other nutrients. For instance, soy sauce is a staple food in cultures from Indonesia to Japan and is enjoyed all over the world.

Despite the thousands of years that food has been fermented, it's likely that the underlying microbial and enzymatic activities that caused the alterations were mostly unknown. Understanding of these processes has lately advanced, as has the way they have been modified for commercialization. The employment of microorganisms to efficiently utilise the supply of natural food and feed supplies as well as the transformation of waste materials offers enormous scope and potential for addressing the rising global food demand. The success of fermentation technology depends critically on the organism's genetic development. The two methods for achieving this goal are mutation and recombination.

Probiotics, prebiotics, and symbiotic are a very intriguing area for research due to the worrisome rise in the inappropriate use of antibiotics and increased bacterial resistance, as well as the increasing interest in ecological approaches to prevent illnesses. Evidence of their positive effects in a range of GI (Gastro Intestinal) and non-GI problems is starting to mount. They provide dietary strategies to support the gut flora's balance. They can be used to treat localised immunological dysfunction, maintain the integrity of the intestinal barrier, stop the spread of harmful bacteria, and modify intestinal metabolism. When it comes to giving revolutionary cures in several disciplines, this field has a bright future.

CHECK YOUR PROGRESS

2. Define fermentation.
   ……………………………………………………………………………………
   ……………………..

3. Define the role of yeast in food industry.

…….

4. Define making process of vinegar.
……….

5. Write the making of beer and wine.
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6. Write the role of lactic acid bacteria in food fermentation.
……
7. Define fortification and enrichment process.
…….
8. Role of enzymes
……..

KEY WORDS

Carbohydrates: Organic compounds that consist of carbon, hydrogen and oxygen. They vary from simple sugars containing from three to seven carbon atoms to very complex polymers.

CFUs: Colony forming units.

Enzyme: A protein that acts as a catalyst. Every chemical reaction in living organisms is facilitated by an enzyme.

Fermentation: Enzymatic breakdown (catabolism) of carbohydrates generally in the absence of oxygen or changes in food caused by intentional growth of bacteria, yeast or mold.

Food: Those substances that are eaten or otherwise taken in the body to: sustain psychological and physiological life support growth and repair and replacement of tissues; and provide energy and nutrition. In essence, the sum of all the processes concerned with the growth, maintenance and repair of the body and/or its organs and systems.

Food processing: Using food as a raw material and changing it in some way to make a food product.

Gastro intestinal: Pertaining to the stomach, small and large intestines, colon, rectum, liver, pancreas, and gallbladder.

Yeast: Single cell organism, which as it grows converts carbohydrates by fermentation into alcohol and carbon dioxide**.**

REFERENCES

- Banwart, G.J. (1979). Basic Food Microbiology, AVI Publishing Co. Inc., Westport, Connecticut.
- Frazier, W.C. and Westoff, D.C. (1996). Food Microbiology, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
- Pelczar, M. Jr., Chan, E.C.S. and Kreig, N.R. (1993). Microbiology, Tata McGraw Hill Inc., New York.
- Garbutt, J. (1998). Essentials of Food Microbiology, Arnold International Student's Edition, London