BLOCK-1 INTRODUCTION TO FOOD SCIENCE AND FOOD DISPERSIONS

Food is anything solid or liquid that, when swallowed, is digested and assimilated. In contrast, the food science is the study of the composition of food and the scientific concepts that underlie its modification, preservation, and decay. is known as Food-Science. Everything from growing and harvesting to processing and packaging to shipping and selling to eating and drinking are covered under the umbrella of food science. The processing methods are classified according to the proportions of proteins, carbohydrates, fat, vitamins, and minerals. In the current scenario, food science deals with the essential physical, chemical, and biological reactions of food during processing but also facilitates knowledge in different dimensions like food processing and engineering, food packaging, protein chemistry, carbohydrate chemistry, lipid chemistry, sensory science, and food safety. It is the need of the hour to focus on the needs of the consumers and demands of the market, as the needs and demands now shift to not only maintaining the shelf life of food products but also maintaining their organoleptic properties.

Unit-1 deals with the **'Introduction to Food Science'.** The unit elaborates on different aspects of food science. This unit also facilitates knowledge regarding the evolution of the food industry and provides a detailed description of the development of allied industries associated with food science.

Unit-2 is about **'Constituents of Food'**. This unit explains the definition, constituents, and chemistry of food. This unit also helps to understand food's properties and significance better.

Unit-3 covers **'Water and Food Dispersions'**. This unit discusses water's physical, chemical, and structural properties. Detailed descriptions of different food dispersions like gel, emulsion, and foam are given. Other terms like water activity, food spores, freezing, free and bound water, and the rheological properties of food are discussed in detail in this unit.

MFN-105- FOOD SCIENCE AND EXPERIMENTAL COOKERY

Unit-1 INTRODUCTION TO FOOD SCIENCE

Structure-

1.0 OBJECTIVE

After reading this unit, students will be able to:

- Know the definition and concept of food science.
- Explain the evolution of the food industry.
- Describe the different allied industries of food science.
- Discuss recent advancements in food science.

1.1- INTRODUCTION- DEFINITION OF FOOD SCIENCE

Food, as it is experienced, is the core of one's being. It is a fascinating topic to learn more about, and one knows its importance and values. In earlier days, humans started experimenting with a wide range of shapes and flavours. Because of this, the art of cooking came into existence. Later some people who developed particular interests became experts and earned names and fame.

Food science and food technology can be defined as.

1.1.1- Food Science: Food science can be defined as applying the study of the fundamental physical, chemical, and biological properties of foods as well as the concepts of food preparation using the basic sciences and engineering.

1.1.2- Food Technology: Food technology is the application of the findings of food science to the tasks of food procurement, storage, processing, packaging, and distribution.

1.2- FOOD SCIENCE AS A DISCIPLINE

The chemistry of food, including carbohydrates, proteins, fats, water, and fibre, and their processing and storage by the body is given considerable attention in the field of food science. Food science encompasses a wide range of subfields, including but not limited to microbiology, engineering, and chemistry. There are some food scientists that are also interested in the psychology of food choice because of the direct interaction food has with humans. These professionals deal with the gastronomic senses. Raw agricultural materials like wheat are processed by food technologists into more refined foods like flour and baked pastries. Chemical and mechanical engineering concepts are also present in the food processing industry. Almost every edible item comes from some sort of living organism. Thus, foods contain **"Edible Biochemical,"** and biochemists often work with foods to understand the chemical effects of processing or storage on their biochemistry. In a similar vein, nutritionists check on goods throughout production to guarantee they stay true to their labelled nutrient profiles. There are also government-employed food scientists who check for quality, safety, and accuracy in labelling.

Within the discipline of food science, closely connected fields are important for a better understanding of food science. The fields' are:

1.2.1 **Sensory Science:** Sensory science and analysis are the methods through which individuals assess flavours, looks, and food textures. Scientists in this industry may develop novel food products and flavours that are either more nutritious or more convenient. For example, they may develop an all-organic frozen lasagna or a new cereal flavour. Others may prefer to conduct quantitative descriptive analysis using a focus group of consumers. Participants may submit numerical evaluations to sensory characteristics during this type of analysis.

1.2.2 **Nutrition:** Some food scientists are interested in finding strategies to keep food's nutritious content while improving its organoleptic properties. This could include fortifying foods with vitamins or folic acid, or recovering nutritional value lost during the milling or goods manufacturing processes via the restoration or enrichment process.

1.2.3 **Food Chemistry:** Understanding food chemistry is critical for producing healthier foods. Food chemists can help extend a product's shelf life, assure consistent texture, and provide more simple ways to produce food by understanding the structure of basic ingredients.

1.2.4 **Microbiology:** This discipline investigates how microorganisms such as bacteria, yeast, and mould interact with food. Food safety professionals may study microbiology to discover how to remove hazardous germs and mould from foods, and then conduct testing to assure consistency throughout their supply chain (from processing to transportation to retail channels to customers). Fermented foods are a subset of the microbiology study of dairy products, soy, drinks, vegetables, and other foods.

1.2.5 **Engineering and Processing:** Food engineers are critical in the transformation of basic ingredients into safe and healthy meals. Process engineers then assist in maintaining flavour, colour, and shelf life by making identical candy bars and deciding on the material of the wrapper. Packaging, such as vacuum-sealed meats, and even genetically engineering apples to produce thicker skins are examples of this.

1.3 EVOLUTION OF THE FOOD INDUSTRY

The food business is a diverse group of enterprises that operate on a worldwide scale and are responsible for providing food and energy to a major section of the world's population. The food processing industry is one of India's most important and significant economic sectors. It ranks sixth in terms of output, consumption, exports, and predicted growth. The food processing business is widely regarded as a 'Sunrise business' in India, with enormous potential for boosting the agricultural economy, establishing large-scale processed food production and food chain facilities, and producing jobs and export revenues. From being the world's second-largest food producer to the world's number-one producer, India has immense growth potential. The word "food processing" refers to the handling of a wide range of commodities originating in several sub-industries such as agriculture, horticulture, plantations, animal husbandry, and fisheries. The transportation of food from the farm to the consumer's plate is a critical component of the food industry.

India's culinary tradition is always evolving in new directions. As a result of urbanisation, increased salaries, an increase in the number of working women, and the proliferation of fast food outlets, the acceptance of pre-packaged and ready-to-eat food products is increasing, particularly among the urban middle class. Food goods that are highly specialised, highly processed or packed, as well as ready-to-serve, ready-to-cook, or reconstitutable, are in great demand.

India is the world's second-largest food producer, trailing only China. India has a production advantage in many agricultural items and the potential to develop a wide range of agricultural raw materials required by the food-processing industry due to its diversified agro-climatic conditions. India is a significant supplier of spices, essential oils, condiments, and fruit pulps.

Small and medium-sized local players who are familiar with the local food habits and marketplaces have a competitive edge in the marketplace as a result of the significant variances in food habits and culinary traditions that can be found across the country. By lowering their pricing, several Indian food-processing companies have been able to grow their share of the market. Imports are made considerably more expensive due to the high import levies placed on processed goods and food products.

As India's total food production is expected to triple in the next 10 years, there is a huge opportunity for major investments in food processing, notably in canning, dairy processing, speciality processing, packaging, frozen food/refrigeration, and thermal processing. The majority of the industry's subsectors have recently expanded rapidly. The food processing sector is one of India's most important industries in terms of production, consumption, exports, and growth potential.

In the recent decade, India has transitioned from a scarcity to a surplus in terms of food. The Indian food processing business is on a definite path to expansion and profitability in the coming decades. In 2018, the packaged food segment grew by double digits, with edible oils and dairy products accounting for a sizable part. Packaged flatbread sales (chapatis, naans, rotis, parathas, and kulcha) have also increased, owing to the introduction of GST and variable serve packs, as well as a lower tax level. Consumer demand for packaged dessert mixes and other premium packaged bakery goods (croissants, filled muffins, etc.) has also surged.

Meanwhile, the breakfast cereal market, rebranded as a healthy snack, is becoming more competitive, with new entries as well as novel versions aimed at health-conscious customers.

Interestingly, with year-round availability of fresh produce, retail demand for frozen vegetables is dropping; but, demand for frozen vegetables is increasing among food service providers. The frozen processed seafood category grew in popularity, as did demand for overseas seafood. Internet retail channels, a growing emphasis on healthful food, and the convenience of long-term storage are further driving growth in the seafood market.

Consumer preferences are shifting towards healthier foods and the convenience of long-term storage. In cereals, the development of varieties such as muesli and granola has disrupted the conventional breakfast cereal product, flakes; in edible oils, there has been a trend towards olive oil and rapeseed oil as favoured edible oils. Meanwhile, the Indian market for naturally healthy beverages and Ayurvedic-based juices has seen tremendous value development. In recent years, organic packaged food has shown double-digit growth in retail volume and current value sales.

Other food segments showing high growth include sauces, soups, noodles and pasta, chocolate confectionary, specialized cheeses (Mozzarella, Cheddar, and Parmesan), etc.

1.3.1 Dairy Processing

India's effectiveness in implementing Operation Flood Programmes has allowed the country to preserve its status as the world's leading milk producer since 1988. Milk is produced, processed, and sold/consumed in India in a way that is completely different from everywhere else in the world. To make the dairy industry sustainable and profitable, almost 70 million rural households (mostly small and marginal farmers and landless labourers) produce milk.

1.3.2 Health Food

Another rapidly growing food market category that is gaining appeal among the health-conscious is health food and supplements. India is one of the world's largest food producers, accounting for less than 1.5 percent of global food commerce. This represents a large opportunity for both investors and exporters.

1.3.3 Value-Added Food Products

India produces milk, rice, wheat, fruits, vegetables, livestock, fish, seafood, and eggs, and the country is among the top producers in the world. In comparison to its agricultural output, its existing food processing facilities are limited. Only 8% of agricultural output is converted into value-added products. However, according to demand, the manufacturing of value-added products in India is expected to increase in the future years.

1.3.4 Fruits and Vegetable Processing-

Ready-to-drink beverages, fruit juices, pulps, dried and frozen fruit and vegetable goods, tomato products, pickles, convenience vegetable-spice pastes, processed mushrooms, and curried vegetables have all showed signs of growth in recent years.

Domestic consumption of value-added fruits and vegetables is low in comparison to processed foods and fresh fruits and vegetables. In India, only a small percentage of fruits and vegetables are processed.

1.3.5 Meat and Meat Processing:

India has the world's greatest livestock population, with 50 percent of the world's buffaloes and 20 percent of the world's cattle, yet only around 1 percent of total meat production is transformed to value-added goods. Poultry meat is India's fastest-growing animal protein in the meat and meat processing business.

Freshly cut meat purchased at a wet market is significantly more popular among Indian consumers than frozen or processed meat items. As a result, large processing companies have been unable to expand their economic interests in this area. Only around 1% of this is processed into value-added products (ready-to-eat or ready-to-cook). Large animals are primarily processed for export.

However, in recent years, as a result of newly emerging health risks from diseases that can be transmitted from animals to humans through meat, consumers of meat have become more vigilant regarding the wholesomeness of the meat, and they are demanding that meat and poultry products be processed in an environment that is clean and sanitary. This demand is a direct result of the growing concern that consumers have regarding the safety of the meat. The demand for "convenience items" such semi-cooked, ready-to-eat, and ready-to-cook meat products are expected to increase in metropolitan regions and other urban areas in the near future. In accordance with the Meat Food Products Order (MFPO) of 1973, a licence is required for the processing of meat products.

[The primary goals of the Meat and Fish Products Organisation Act of 1973 are to regulate the production and sale of meat food products through manufacturer licencing, to enforce the sanitary and hygienic conditions prescribed for the production of wholesome meat food products, and to exercise stringent quality control at all stages of the production of meat food products, fish products, including chilled poultry, and so on.

1.3.6- Ethnic Food/Street Food-

In industrialised countries, the concept of a traditional food street has taken on new meaning, with food streets emerging as new tourist attractions. Food streets in major tourist locations are typically filled with interesting local cuisine. Street food has long been popular in India due to its low cost and easy accessibility.

This is an area with enormous potential for greater revenue creation for merchants as well as a boost to the tourism sector. This may also increase the popularity of local cuisine traditions, such as fast food, which is popular among Indians.

1.4 CHALLENGES FOR THE FOOD INDUSTRY

The food and beverage business is a consumer-driven, multibillion-dollar vertical industry that, while demonstrating admirable, excessive growth, is nevertheless beset by a number of challenges. People are becoming more nutrition-conscious, preferring fat- and sugar-free foods, and are generally more inclined to maintain good health. This school of thought is supported by the notion that food products are evaluated based on their quality and nutritional value. This dynamic thought process has compelled food companies to implement substantial modifications in the present manufacturing process in order to effectively address some of the food and beverage market's critical difficulties.

1.4.1- The 'Plastic Ban'

The steady growth rate of industrialization, of which the food and beverage sector is a vital arm, had a terrible influence on the environment, which has become one of the major difficulties confronting food and beverage management today. Food and beverage makers and merchants are currently working to make the food manufacturing process more environmentally friendly by implementing a variety of recycling practises. Green business practises, from production to packaging and supply chain management, are critical to addressing contemporary food industry concerns.

Another environmental component that contributes to the current issues of the food and beverage industry is waste management. The food sector generates significant waste, from raw material procurement to food retailing and distribution. The detrimental impact has been identified as one of the most critical environmental challenges in the food and beverage industry, which must be addressed promptly.

1.4.2- **The rise of health-consciousness among consumers-**

Food-related problems are becoming more common, prompting consumers to adjust their diet and lifestyle, making them more health-conscious than ever. As a result, one of the most difficult tasks in the food and beverage industry is for producers to provide nutritious goods that deliver adequate nutrients while not detracting from the brand's attractiveness. This has resulted in a variety of nutrient-dense foods appearing in supermarket aisles labelled 'gluten-free,' 'dairy-free, ‘sugar-free,' and so on. The vast proliferation of the food supplement ingredient business is an excellent example of justification for the aforementioned.

Another trend that is at the heart of the issues that food and beverage managers face is the growing desire for organic products. The sharp decline in demand for processed foods has propelled the organic food sector, raising awareness of natural foods' good health effects. This has boosted demand for natural, nutritious foods, propelling organic rice protein market trends.

1.4.3- **The rising concerns about product traceability-**

Traceability is a crucial concern in the food and beverage business, not just for record management but also for meeting the bottom line—generating money for all sectors. Consumers' increasing interest in knowing what goes into their food has resulted in 'ingredient labelling' being an important aspect of the packaging process. End-to-end traceability has emerged as one of the current trends in the food and beverage industry, with public faith in food supply chains dwindling and awareness of flaws in the F&B supply chain expanding over the previous decade.

1.4.4- **The ascent of the meat-free and veganism trends**

The increased concern for animals is causing a shift in people's eating habits. As more consumers choose vegetarian and vegan products, demand for meat and other products has decreased dramatically, providing a big issue in the food and beverage business. People prefer purchasing products with labels such as "humane-certified" and "cage-free" because social platforms and internet information portals have opened the path for animal abuse awareness.

1.4.5- The pervasive presence of e-commerce

An online presence is a significant challenge in the food and beverage industry, considering consumers are more tech-savvy and socially informed. Undeniably, the challenges faced by food and beverage managers are a dime a dozen, owing to the ridiculously fierce competition and the fact that a single change is bound to affect the entire supply chain. Newer markets, changing consumer spending, increasing food prices, global appetite, and advanced technology will bring about extensive changes in this sector in the next few years. Despite the consistent challenges facing the food and beverage industry, it is predicted to show healthy gains in the future. It is unclear how the global F&B market will perform in the coming years as a result of rising disposable income, shifting lifestyles, and beneficial government reforms.

1.5 NEW OPPORTUNITY FOR FOOD PROCESSING INDUSTRY IN INDIA

The uniform market size of India, along with rising incomes and changing lifestyles, has provided great market prospects for food producers, machinery manufacturers, food technology and service suppliers. The food processing business has a high potential for export and employment. Investor-friendly policies are in place, and the country has ample technology and human resources. However, poor quality perceptions and an unfavourable image of Indian products are preventing Indian food products from making significant inroads into worldwide markets.

The production of high-quality processed meals that fulfil international quality standards and regulations could open up new markets for Indian food goods. This will help India to become a prominent player in the global food market by creating a dynamic and competitive local food processing industry. A shift in attitude towards quality is required.

1.6 MAIN INITIATIVE FOR FOOD PROCESSING INDUSTRY IN INDIA

1.6.1- Cold Chain: To address the situation and create a modern cold chain for the preservation and value addition of perishables

1.6.2- Mega Food Parks- A new mega food park project in the country is suggested, with each park including a well-defined agri-horticultural processing zone with state-of-the-art processing equipment, support infrastructure, and a well-established supply chain. The Mega Food Park is intended to eventually connect farmers with retail markets while minimising intermediaries. a vibrant and competitive local food processing industry, allowing India to become a prominent player in the global food market. A shift in attitude towards quality is required.

1.6.3- Abattoirs-

The Indian meat business is concerned on sanitary and scientific slaughtering, as well as the best use of by-products. It causes massive waste, contamination, and unnecessary cruelty to animals. The ministry is initiating a comprehensive initiative to upgrade existing abattoirs and build modern abattoirs.

1.6.4- Food Parks-

The government is working on agri-zones and the concept of mega food parks to help the food sector. Twenty mega parks will be built in various cities around the country to attract Foreign Direct Investment (FDI) in the food processing sector. Between January 2002 and May 2005, the government authorised 105 bids from foreign manufacturers to establish food processing factories in India, total Rs. 643.47 crore (US$ 144 million).

1.7 DEVELOPMENT OF ALLIED INDUSTRIES OF THE FOOD INDUSTRY

In terms of growth, production, consumption, and exports, India's food processing industry is among the largest in the country. Meat, poultry, fisheries, fruits, vegetables, spices, milk and milk products, alcoholic drinks, plantations, and cereals are all produced by the industry. In India, there are various additional businesses that are closely related to the food industry and are referred to as "allied industries" of the food industry. Food and processing industries are related with the following fields or sectors:

1.7.1- **Food Chemistry:** Because foods are inherently biological molecules that are highly changeable and complicated, food chemistry is a constantly evolving and increasing branch of knowledge that underpins other fields of food science. Food chemists work to identify the composition and qualities of food, as well as to understand the chemical changes that occur throughout production, storage, and consumption and how they might be managed.

1.7.2- Food Analysis: This field deals with the basic properties of foodstuffs and different instrumental methods for determining their composition.

1.7.3- **Food Biochemistry:** Food science is an interdisciplinary field that requires knowledge of microbiology, chemistry, biology, biochemistry, and food system engineering. Understanding biochemical processes is essential for controlling many elements of food properties and stability.

1.7.4- **Food Biotechnology:** Biotechnology has been broadly defined as utilizing biologically derived molecules, structures, cells, or organisms to carry out a specific process. Many conventional food processing techniques utilize living organisms and bioactive molecules, especially in the brewing and fermentation industries.

1.7.5- **Food Microbiology:** This field discusses the microorganisms essential to the food industry, including viruses, bacteria, yeasts, protozoa, and worms. The field experts associated with the examination of microbial growth and methods of measuring these microbial growths.

1.7.6- **Food Processing:** Food processing involves different cleaning, separation, size reduction, combining, heating, cooling, and packaging activities that convert basic food resources into high-quality, nutritious products. We become dependant on indigenous, in-season foods if food processing is not available. Food processing increases shelf life while also adding variety and a more sensory eating experience.

1.7.7- **Food Engineering:** In a food processing plant, raw food is converted and processed into desired products using a variety of equipment. In designing food processing equipment for any given purpose, an engineer must consider numerous criteria that are inherent to the process. So this industry is mostly associated with designing food processing equipment.

1.7.8- **Food Packaging**- Food processing involves different cleaning, separation, size reduction, combining, heating, cooling, and packaging activities that convert basic food resources into high-quality, nutritious products. We become dependant on indigenous, in-season foods if food processing is not available. Food processing increases shelf life while also adding variety and a more sensory eating experience.

1.7.9- **Nutrition:** In the present scenario, not only is nutrition shaping the development of new food products, but technological innovations have helped create a range of nutritious and functional foods.

1.7.10- **Sensory Evaluation:** Sensory evaluation is a science that measures people's reactions to items as perceived via their senses. Understanding human behaviour and the physiology of the senses is essential for acquiring useful information. The impact of physical features on sensory characteristics and, ultimately, how they affect consumer preference and purchasing behaviour is an important rationale for sensory testing of processed food products.

1.7.11- **Quality Assurance and Legislation**: Consumers want safe food, and legislation is being drafted to assist assure this. Food scientists and technologists play an important part in the manufacture of safe and healthful food that satisfies the needs of customers. They are responsible for ensuring that necessary inspections on suppliers are performed, establishing effective quality procedures, and assisting in the maintenance of product safety and quality.

1.7.12 Regulatory Toxicology-The presence of potentially hazardous compounds in food is a global public health concern, and most countries handle these potential dangers through regulatory toxicology. Different regulatory toxicology agencies evaluate animal and other research to characterise dangers and, when possible, determine safe or tolerable levels based on adequate levels of protection.

1.8 LET US SUM UP

In this unit, we have discussed the definition and concept of food science and food technology. After that, we have a detailed description of food science as a discipline, as different disciplines are closely associated with it, like food microbiology, food chemistry, sensory science, etc. This unit also facilitates knowledge about the evolution of the food industry, in which we have discussed some major industries of the food industry, including the dairy industry, fruit and meat processing industries, and value-added and ethnic food products, which have shown major evolution in recent years. The major challenges of the food industry, like plastic bans and veganism, were also discussed in the unit, and at the same time, major opportunities in the food industry were also marked in this unit, like cold chains and mega food parks. The different allied industries of food science were also discussed in the unit.

After going through this unit, a complete knowledge of different aspects of food science as a discipline and the food processing industry must be facilitated.

Food Science Food Science can be defined as the study of the fundamental physical, chemical, and biochemical nature of

	foods as well as the fundamental principles of food processing through the application of the fundamental sciences and engineering.
Food Technology	Food technology is the application of the knowledge gained from food science to the activities of food selection, preservation, processing, packaging, and distribution, with the goal of ensuring that consumers are consuming food that is not only healthful but also safe.
Food Processing	The processing of food is often a mechanical process that involves the use of equipment for extrusion, massive mixing, grinding, chopping, and emulsifying in the preparation of the final product.
Value Added Products	A change in the physical state or form of the product in a manner that enhances its value.
Cold Chain	The cold chain is defined as the series of actions and equipment applied to maintain a product within a specified low-temperature range from harvest or production to consumption.
Mega Food Park	Mega Food Park is a scheme of the Ministry of Food Processing to establish a "direct linkage from farm to processing and then to consumer markets" through a network of collection centers and primary processing centers.
Sensory Evaluation	Sensory analysis is a scientific discipline that applies principles of experimental design and statistical analysis to the use of human senses to evaluate consumer products.

CHECK YOUR PROGRESS EXERCISE

1- What do you understand by the term “Food Science”?

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2- Write down a short note on “Challenges for the Food Industry”.

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3- Briefly explain the new opportunities for the food processing industry.

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4- Write down about Allied Industries of Food Science.

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Fill in the Blanks-

1. A process that changes the physical state or form of the food product in a manner that enhances its value is known as …………………………..
2. A scientific discipline that applies principles of experimental design and statistical analysis to the use of human senses to evaluate consumer products is known as…………………..
3. A series of actions and equipment applied to maintain a product within a specified low-temperature range from harvest/production to consumption is known as ………………………

4. ……………………….. field deals with the basic properties of foodstuffs and different instrumental methods for the determination of the composition of foodstuffs.

State whether the statement is True or False-

1. Food processing transforms raw food materials through a variety of methods into high-quality, nutritious products.
2. **2.** Food biotechnologists attempt to define the composition and properties of food and understand the chemical changes undergone during production, storage, and consumption.
3. **3.** Food science is the use of the information generated by food science in the selection, preservation, processing, packaging, and distribution of food.
4. **4.** Mega Food Park is a scheme of the Ministry of Food Processing.

UNIT-2 CONSTITUENTS OF FOOD

Structure-

1.0 OBJECTIVE

After reading this unit, students should be able to-

- Understand the major properties of Food
- Know the significance of different properties of Food
- Know the constituents of food and their properties and significance

1.1 INTRODUCTION TO MAJOR PROPERTIES OF FOOD

Food has two crucial properties: nutritive value and hedonic value. The former is relatively easy to assess because key nutrients are scarce, and their effects are well characterized. It is more difficult to define taste since it must take into consideration all the aspects of food that interact with our senses, such as visual appeal, smell, taste, and texture. A wide number of chemicals, some of which have yet to be found, alter these qualities. Foods are increasingly being appraised based on qualities that determine how they are handled, in addition to their nutritional and hedonic merits.

1.1.1 Physical Properties of Foods-

It is possible to define the physical qualities of food in a broad sense as those properties that are more amenable to being described and quantified using physical means as opposed to chemical means.

a) Geometrical Properties- These include size, shape, volume, density, and surface area as applied to homogeneous units. Texture's geometrical properties apply to structural geometry and structurally heterogeneous foodstuffs.

- **Size and Shape-** Fruits and vegetables are divided into 13 shapes, including round, oblate, oblong, conic, elliptical, truncated, ribbed, and so on. Sphericity is the most used method for quantitative shape description, also:

  Sphericity = de/dc

  Where de is the diameter of a similar shape to the test object and dc is the diameter of the smallest circumscribing sphere (usually the longest diameter of the test object). Size is typically defined by defining the opening, such as in a sieve or screen, through which the product will or will not pass, as well as measuring the diameter or length of the product.
- **Volume, Density and Surface Area**- The only issue with measuring the volume and density of liquid foods is ensuring that the temperature at which they are measured is properly controlled. Standard volumetric methods (graduated cylinder) for measuring volume are easy, as are

pycnometers and commercial density meters for measuring density. Typically, the volume of agricultural goods, particularly those with an irregular shape, is governed by water displacement. Solids' density can be evaluated by floating them in liquids (often salt solutions) of varying densities. Certain agricultural produce's (peas, lima beans, potatoes) density is also an indirect indicator of their texture. Separation by density in floatation is also used to eliminate faulty components and extraneous substances from a variety of agricultural products. Density can be measured and characterized in several different ways, including actual density, material density, particle density, apparent density, and bulk density. In heat transmission, surface area values are relevant. Several methods for calculating the surface area of products, such as fruits, based on shape factor measurement have been developed (e.g., areas of axial or longitudinal cross sections).

b) Optical Properties- The color and surface appearance (gloss) of the produce are the most crucial optical characteristics from a quality standpoint. Along with some spectrophotometers that measure light in both transmittance and reflectance modes, these instruments work with reflected light. Defects like apple water cores may be found using transmitted light.

- **Color-** It is one of the most essential characteristics, capable of distinguishing high-quality produce (such as the brilliant yellow of a table orange) or alerting the consumer to a potential psychological hazard (such as green processed meat). It also infers flavor requirements in products like beverages and dessert gels, and it influences consumer impressions. The spectrophotometric method for describing color is based on three parameters: reflectance (lightness), dominant wavelength, and purity. The color scales L, a, and b are employed in this Hunter color lab equipment. L represents brightness, a represents red-green lines, and b represents blue-yellow lines.
- **Gloss-** The appearance of a surface, whether shiny or drab, is a significant physical feature of food quality that human vision detects. Apples,

cucumbers, and cherries are examples of items with a shiny surface, whereas oranges, green beans, and other vegetables have a dull surface. The psychological quality of gloss in surfaces connected with the spectrum reflects and varies from surface to surface.

1.1.2- **<u>Rheological Properties of Food</u>**-

Some of the reasons for documenting individually the flow behavior of distinct foods are the complex nature of foods, their variability, and their unique behavior. There are two basic categories for evaluating the rheological qualities of solid foods. Fundamental tests examine material properties that are independent of sample shape, loading situation, or apparatus, such as modulus of elasticity, Poisson ratio, relaxation duration, and shear modulus. Empirical or imitator tests are used to determine attributes such as piercing force and extrusion energy, where the mass of the sample, geometry, test speed, and other factors all contribute to the estimated value. The fundamental tests for solid foods can be separated into two groups: those performed under static (quasistatic) loading circumstances and those performed under dynamic ones. Fluid foods are those that flow under gravity and do not hold their structure. Foods can exist as solids at one temperature and as liquids at another (such as ice cream), and solid matter suspensions can be fluid media or emulsions. Foods have flow behavior ranging from simple Newtonian to time dependent non-Newtonian and visco-elastic due to the enormous variety of their structure and content. Raw whole egg, for example, was discovered to be a Newtonian fluid at 21 degrees Celsius. Frozen egg, on the other hand, was discovered to be a shear-thinning fluid.

1.1.3 **<u>Thermal Properties of Food</u>**-

Thermal characteristics are critical for understanding heat transport throughout the heating and cooling processes that meals are constantly subjected to. All food products have varying compositions and physical qualities. The key thermal parameters are specific heat, enthalpy, thermal conductivity, thermal diffusivity, and heat transfer coefficient. When building a food heating/cooling system, these are often used qualities. Melting/freezing point, latent heat, heat of respiration, heat of adsorption, coefficient of thermal expansion, dielectric constant, emissivity, and absorptivity (radiation heat transfer) are other thermal properties that are important in most heat transfer applications.

1.1.4 <u>Mass Transfer Properties of Food</u>-

Mass transfer is crucial in food processing's basic unit processes. It's also employed in physical, chemical, and biological food processes like salting, sugaring, oxygen absorption, de-aeration, and process equipment cleaning. Moisture, vapors/gases, and flavour components can all have an impact on food quality during manufacturing and storage.

1.1.5 <u>Electrical Properties of Food-</u>

These characteristics govern how much energy is coupled by a food product and how it is distributed throughout the product. Electrical characteristics and dielectric properties are important in high frequency food processing because they influence various related electrical parameters that affect energy coupling and distribution within a food product. In terms of their ability to store and discharge electrical energy from an applied electromagnetic field via radiation transfer, biological materials serve as heavy insulators or non-ideal capacitors. These characteristics are characterised by fundamental dielectric qualities and result from electric charge and reduced current in general.

1.2 INTRODUCTION TO MAJOR CONSTITUENTS OF FOOD

It is critical to have a thorough grasp of the food elements and their interacting behavior to process foods by converting raw materials into creative, desirable, attractive, and appealing products that are both safe to consume and have year-round consistency. Foods, by definition, are complex and multi-component in composition. Foods, in addition to water, contain carbs, proteins, fats, and oils. Flavors, vitamins, minerals, and chemicals such as preservatives are also included in minor but significant concentrations. Not all foods include all of these ingredients in equal amounts.

1.2.1- <u>Water</u>

Water makes up more than 70% of our body weight and is a necessary component of all human cells. Water is required for all biological activities in our body. Water accounts for two-thirds of a human body's weight. It not only maintains body temperature but also eliminates waste. As a result, water is an essential component of a well-balanced diet. Although water does not provide energy, it is a necessary nutrient. It serves the following functions in the body:

1. Water transports food, waste, gases, and other substances (including hormones) throughout the body.
2. Water promotes digestion by dissolving nutrients, which the body then absorbs or digests.
3. Water carries waste from the body in the form of sweat and urine.
4. Water contributes in the control of body temperature.

An individual's water requirements are dictated by their age, occupation, and climate. Athletes and people who do a lot of hard labour must drink a lot of water since they sweat a lot. Our bodies require more water in the summer than in the winter for the same reason.

1.2.2- <u>Moisture</u>

Moisture is present in all food materials. It exists in two forms: free water and bound water. It is one of the most essential food material properties that influences food processing, preservation, and storage. Water accounts for 50-60% of the human body weight. Fruits and vegetables have 90 percent to 99 percent moisture, fruit juices have 80 percent to 89 percent moisture, pasta, beans, beef, and dairy have 10 percent to 60 percent moisture, while crackers and cereals have 1 percent to 9 percent moisture.

1.2.3- <u>Carbohydrates</u>

The majority of carbs in the diet come from plant sources. Simple carbohydrates are made up of different forms of sugar (monosaccharides and disaccharides), whereas complex carbohydrates (polysaccharides) include starches and dietary fibre. They have the formula Cn(H2O)n and are composed of carbon and water. Although no single carbohydrate is required, carbs play an important part in numerous body functions. Carbohydrates are categorised in the following ways.

• **Monosaccharides-** It can have six carbons (known to as hexoses) or five carbons (referred to as pentoses). Glucose (dextrose), fructose, and galactose are the three most common hexoses. Ribose and deoxyribose are two of the most frequent pentoses.

• **Disaccharides-** A disaccharide is created by putting two monosaccharides together. The most common disaccharide is sucrose (sugar), which consists of one molecule of glucose and one molecule of fructose. Lactose, the predominant sugar in milk, is made up of one glucose molecule and one galactose molecule. Maltose is a disaccharide made up of two glucose molecules.

• **Polysaccharides-** When two or more sugars are joined, they are referred to as oligosaccharides until they are particularly large, in which case they are referred to as polysaccharides. Raffinose and stachyose are two oligosaccharides. Polysaccharides are nutritionally added to increase fibre content and functionally added to thicken, form gel, bind water, and stabilise proteins. Starch, cellulose, and gums are the most common polysaccharides.

Carbohydrates in the form of glucose are consumed by the cells. After being absorbed from the small intestine, glucose is processed in the liver, where it is stored as glycogen, a starch-like substance, and the remainder is released into the bloodstream. When there is glucose present, triglycerides can be broken down into ketones. The bloodstream carries glucose to the muscles and organs for oxidation, while excess quantities are stored as fats to be retrieved during low carbohydrate times. Complex carbohydrates, such as unprocessed grains, tubers, vegetables, and fruits, provide the most nutrients and are high in proteins, vitamins, minerals, and lipids. Sweets and soft drinks made from refined sugar are a less beneficial source because they are high in calories but low in nutrients.

Carbohydrate Functions-

- Carbohydrates offer energy for the body's appropriate operation.
- Carbohydrates also store food in the body for the contingency period.
- Carbohydrates are the building blocks of nucleic acids.
- Carbohydrates also help animals' skeletal systems.
- Carbohydrates add sweetness and flavour to foods.
- Carbohydrates help to break down fatty acids.

1.2.4- Protein

Amino acids are the building components of protein. Plants and animals provide dietary protein. Proteins are polymers of amino acids. The sequence of a protein's amino acids determines its structure and consequently its function. Proteins must be hydrolyzed (broken down) into amino acids before they may be utilized. Once absorbed, amino acids are used to make proteins, converted to energy, or stored as fat. Protein constitutes around 20% of the human body.

Amino acids have an amino group (-NH2) and an acid group (-COOH). Proteins include twenty amino acids. Peptide bonds are formed when amino acids combine. A protein molecule's native conformation is dictated by its primary structure, secondary structure, and tertiary structure.

- **Primary**- The fundamental structure is formed by combining amino acids in the correct sequence via peptide bonds. This structural level classification implies no other forces or bonds.
- **Secondary-** A pleated or helical structure is an example of secondary structure. The alpha helix is held together by hydrogen bonding between the carboxyl and amide groups of the peptide bonds, which exist in a regular sequence along the amino acid chain.
- **Tertiary**-A tertiary structure is the folding of a coiled chain or chains. Covalent, hydrogen, and Vander Waals forces may all have a role in the structural arrangement of protein molecules.

As they are more easily digested and absorbed by the body, animal proteins are considered superior to vegetable proteins. Adult protein needs are around 1 gramme per kilogram of body weight per day. Due to their constant growth, children may require 2 to 3.5 grammes of protein per kilogram of body weight.

Additionally, proteins aid in the repair of damaged tissues. Proteins can also be employed as a source of energy during famine. Approximately 4 calories are produced when one gramme of protein is burned. The fundamental tasks of proteins include the construction and repair of human tissues, the regulation of body processes, and the synthesis of enzymes and hormones such as insulin, which regulate communication between organs and cells, as well as other complicated chemicals that govern body processes. Animal and plant proteins are broken down by digestive enzymes called proteases into nitrogen-containing amino acids before they are utilized. Proteases break the peptide bonds that connect the ingested amino acids, allowing them to be absorbed via the intestine into the blood to recombine into the required tissue.

Proteins facilitate the development of antibodies, which enable the immune system to combat infection. Proteins are an important energy source. There are numerous types of proteins, each of which has a specific purpose in the body. Proteins, along with water, constitute the majority of the human body. Enzymes are chemical compounds that participate in many chemical processes. Enzymes are protein-based substances. For instance, salivary amylase is an enzyme secreted by the salivary glands that converts starch to sugar.

Functions of Proteins-

- Proteins are the primary players in the cell, carrying out the functions defined by the information contained in genes.
- Proteins are necessary for general body growth.
- Proteins act as a bio-catalyst and a biotic regulator.
- Proteins give rapid energy, which is extremely important during an emergency.
- Proteins aid in the catalysis of metabolic reactions.
- Proteins are required for the replication of DNA.
- Proteins actively aid in the movement of chemicals throughout the body.

Types of Protein-

• **Enzymes**- Enzymes perform a crucial function in the breakdown of substances. Enzymes are also essential for cell digestion and development.

• **Structural Proteins**- These proteins provide cells, tissues, and organs strength.

• **Signalling Proteins-** These proteins help cells communicate with one another by sending signals. Defensive proteins assist organisms in fighting infection and assisting damaged tissue in mending quickly.

• **Hormones**- Some hormones are proteins that aid in metabolic processes.

1.2.5- Lipids-

Lipids consist of plant and animal fats and oils. Food components that are soluble in organic solvents are lipids. Included in this category are fatty acids, triglycerides, phospholipids, pigments, vitamins, and cholesterol. Fatty acids found in nature contain an even number of carbons. Reaction products of long-chain fatty acids have an essential role in the flavor of foods.

• **Fatty Acids**- Fatty acids can be saturated or unsaturated (have double bonds). Monounsaturated fatty acids have one double bond, while polyunsaturated fatty acids have two or more double bonds. Unsaturated fatty acids can be cis or trans, based on the configuration of the regions of the fatty acid molecules around the double bonds. Lipid double bonds are extremely reactive to oxygen.

• **Triglycerides**- Triglycerides are fat components present in meals that are made up of three molecules of fatty acids connected to one molecule of glycerol. The vast majority of foods include some level of fat in the form of triglycerides. Lipases enzymes are in charge of separating triglycerides, which results in the formation of soapy items. A di-glyceride is a molecule of triglyceride from which one fatty acid has been removed, whereas a mono-glyceride is a molecule from which two fatty acids have been removed.

• **Phospholipids**- Some fatty acids are connected to phosphorus-containing glycerol molecules. These distinct lipids are phospholipids like lecithin. They provide important functions in the body, but they are not necessary nutrients because the body can produce enough of them.

• **Cholesterol**- Cholesterol is a naturally occurring chemical that has received a lot of attention because of its alleged link to heart disease. Some people have a congenital problem with the mechanism that regulates cholesterol synthesis, resulting in excessive cholesterol production. In general, these people have much higher serum cholesterol levels. Because elevated serum cholesterol is a risk factor for coronary heart disease, this is cause for concern.

The majority of the food we eat supplies energy for our everyday activities. The remaining food is converted into fat and stored in the body. As a result, fats act as an energy bank in the body, supplying energy whenever it is needed. The majority of fat is stored beneath the skin and serves to protect internal organs from jolts and shocks. Vitamins A, D, E, and K are soluble in lipids, which aids absorption. Fats also enhance the flavour of meals. Because fats take longer to digest, we do not feel hungry for long after eating fried meals.

Functions of Fat-

• Fat is a necessary dietary need.

• Fat is usually the stored source of energy in the body that is stored beneath the skin.

• Fat serves as a protective layer, particularly in the human body, and provides protection.

• Some vitamins, such as vitamin A, D, E, and K, are fat-soluble, which means they can only be absorbed, digested, and transported in conjunction with fats.

• Fats actively contribute to the maintenance of good skin and hair.

• Fats protect body organs from external trauma.

• Fats also help to keep the body temperature stable.

• Fats support proper cell activity.

Types of Fats-

1- Unsaturated Fats-

- Unsaturated fats are fats that remain in liquid form at room temperature.
- Unsaturated fats are advantageous to health since they lower blood cholesterol levels, stabilise heartbeats, and so on.
- Vegetable oils, almonds, and many seeds are high in unsaturated fats.

2- <u>Saturated Fats</u>-

- Saturated fats have no double bonds between the carbons in their chain.
- Saturated fats may easily solidify and are normally found in solid form at room temperature.
- Saturated fats are present in animal meat, cheese, ice cream, and other dairy products.

1.2.6- <u>Vitamins</u>-

Vitamins are chemical substances that stimulate the breakdown of proteins, carbohydrates, and lipids. Without vitamins, food could not be broken down. Certain vitamins aid in the formation of blood cells, hormones, chemicals in the nervous system, and genetic material. Vitamins are divided into two categories: fat-soluble and water-soluble.

<u>Fat-soluble Vitamins- Includes vitamin A, D, E and K</u>

Typically, they are absorbed with fatty foods, further broken down by bile, and the emulsified molecules travel through the lymphatic and venous systems before being delivered to the arteries. Extra calories are stored in the liver, kidneys, and fat cells. As they are perishable, they are not required to be consumed every day.

- **<u>Vitamin A</u>**- It is crucial for epithelial cell health and appropriate development. Due to the deficiency's impact on the retina, skin changes and night blindness or failure to adjust to the dark result. It can be derived through animal-based foods such as milk, eggs, and liver. In developing nations, it is derived from the carotene found in green and yellow fruits and vegetables.
- **<u>Vitamin D</u>**- It functions as a hormone and affects the absorption and metabolism of calcium and phosphorus. Some vitamin D can be gained from eggs, fish, liver, butter, margarine, and milk, but the majority of

vitamin D is obtained via direct sunlight. Its deficiency leads to childhood rickets and adult osteomalacia.

- **Vitamin E**- It is important for many vertebrate species, but its function in the human body remains unknown. There is no conclusive proof that it treats any ailment. It is present in vegetable oils and wheat germ.
- **Vitamin K**- It is essential to blood clotting. It aids in the formation of prothrombin, which is required to create fibrin for blood clots. In addition to being created by bacteria in the colon, vitamin K is also found in leafy green vegetables and egg yolk.

Water-soluble Vitamins: Includes vitamin C and B complex

- **Vitamin C**- They must be ingested every day to replenish body demands because they cannot be stored. In addition to preventing scurvy, vitamin C is crucial for the synthesis and maintenance of connective tissues. Citrus fruit is the main source.
- **Vitamin B complex**- Thiamine (B1), riboflavin (B2), nicotinic acid (also known as niacin), pyridoxine (B6), pantothenic acid, lecithin, choline, inositol, paraaminobenzoic acid (PABA), folic acid, and cyanocobalamin are the essential B-complex vitamins (B12). These vitamins guard against illnesses like pellagra and beriberi by assisting in a variety of metabolic processes in the body. They are present in liver and yeast.

List of Vitamins and Diseases/Disorders Caused by its Deficiency

Vitamins	Chemical Name	Solubility	Deficiency disease
Vitamin A	Retinol	Fat	Night blindness, keratomalacia, etc.
Vitamin B1	Thiamine	Water	Beriberi
Vitamin B2	Riboflavin	Water	Ariboflavinosis, glossitis, etc.
Vitamin B3	Niacin	Water	Pellagra
Vitamin B5	Pantothenic acid	Water	Paresthesia
Vitamin B6	Pyridoxine	Water	Anemia

Vitamin B7	Biotin	Water	Dermatitis
Vitamin B9	Folic acid	Water	Megaloblastic anemia
Vitamin B12	Cyanocobalamin	Water	Pernicious anemia
Vitamin C	Ascorbic acid	Water	Scurvy
Vitamin D	Cholecalciferol	Fat	Rickets
Vitamin E	Tocopherols	Fat	Hemolytic anemia (in children)
Vitamin K	Phylloquinone	Fat	Bleeding diathesis

Functions of Vitamins-

- Like hormone, vitamin D regulates and helps in mineral metabolism.
- Vitamin D also regulates and helps cells and tissue growth.
- Vitamin C and vitamin E act as antioxidants.
- Vitamin B complex acts as co-enzymes or the precursors of enzymes and helps them ascatalysts in metabolic activities.

1.2.7 Minerals-

The structural makeup of both hard and soft bodily tissues must include inorganic mineral components, which also take part in activities including the function of the enzyme system, muscle contraction, nerve reactions, and blood clotting. The diet needs to contain the essential nutrients copper, cobalt, manganese, flourine, zinc, and the main elements calcium, phosphorous, magnesium, iron, iodine, and potassium.

- **Calcium** helps to create bone, maintains the health of the heart, muscles, and digestive system, as well as the synthesis and operation of blood cells. Dairy products, fish in cans with bones (salmon, sardines), leafy green vegetables, nuts, and seeds are all good sources of calcium for the diet.
- **Phosphorus** plays a variety of biological roles, including digesting energy and being a component of bones. It plays a significant part in the cell's energy metabolism and mixes with calcium to form the bones and teeth.

- **Magnesium** is necessary for processing human metabolism as well as sustaining nerve and muscle cells' electrical potential. Malnourished individuals, particularly drinkers, might have deficiency, which can cause tremors and convulsions.
- **Sodium,** A systemic electrolyte, can be found in extracellular fluid where it regulates the electrolyte balance. Edema can result from excessive use. It is now clear that using too much table salt, which contains sodium chloride, causes high blood pressure.
- **Iron** is essential for the synthesis of several proteins and enzymes, most notably haemoglobin. Red meat, leafy green vegetables, fish (tuna, salmon), eggs, dried fruits, legumes, whole grains, and enriched grains are all good sources.
- **Iodine** is required for thyroid hormone synthesis. Goiter can be caused by a deficiency. Traces elements are inorganic substances that present in minute levels in the body and are necessary for optimal health. They include copper, which is a necessary component of many redox enzymes. Its insufficiency is linked to the inability to utilize iron in the synthesis of haemoglobin. Zinc forms enzymes, and its shortage impairs tooth and bone formation. Fluoride is essential for preventing bone demineralization. Chromium, molybdenum, and selenium are among more trace elements.

Major Minerals-

Minerals	Deficiency disease	Sources
Potassium	Hypokalaemia	Sweet potato, potato, tomato, lentils, banana, carrot,orange, etc.
Chlorine	Hypochloraemia	Table salt
Sodium	Hyponatremia	Table salt, sea vegetable, milk, etc.
Calcium	Hypocalcaemia	Eggs, canned fish, dairy products, nuts, etc.
Phosphorus	Hypophosphatemia	Red meat, fish, bread, dairy products,

		rice, oats, etc.
Magnesium	Hypomagnesemia	Legumes, nuts, seeds, spinach, peanut butter, etc.
Iron	Anaemia	Meat, seafood, beans, nuts, etc.
Zinc	Hair loss, diarrhoea	Red meat, nuts, dairy products, etc.
Manganese	Osteoporosis	Grains, nuts, leafy vegetables, legumes, seeds, tea,coffee
Copper	Copper deficiency	Seafood, oysters, nuts, seeds
Iodine	Goitre	Grains, eggs, iodized salt

1.2.8 <u>Phytochemicals</u>-

Phytochemicals have a wide range of physiological and pharmacologic effects. Active derivatives taken from plant leaves, stems, roots, flowers, and fruits can be divided into three categories:

1. Toxic with no clear medicinal application, such as pyrrolizidine alkaloids, nicotine, and hydrazine derivatives.

2. Toxic but effective for illness therapy when taken in controlled levels; for example, morphine, digitalis, and vinca alkaloids.

3. Chemopreventative, beneficial in the treatment of disorders such as arteriosclerosis, cancer, and diverticular disease

The most active chemopreventative phytochemicals are celluloids, pectins, and lignins, as well as low-molecular-weight compounds like carotenoids, dithiolthiones, flavnoids, indole carbinols, isothiocyanates, mono- and triterpenoids, and thioallyl derivatives.

<u>Role of Water and Water Activity in Food</u>-

Food production and processing necessitate vast amounts of different quality water. The food sector needs to design reasonable water usage management plans that maximise health protection as awareness of the intimate relationship between water and food borne disease grows. Water, like food, is a vector for the spread of numerous pathogens and continues to cause substantial disease outbreaks in both industrialised and poor countries around the world. Food can also be contaminated by water. Food contamination during primary production can contribute to the spread of food-borne disease.

Water is a vital natural resource for the food processing industry since huge volumes are required to meet processing demands. Water is used for cleansing, nutrient transport, plasticization, dilution, and food production. It has a significant impact on all chemical reactions and changes in physical state that occur throughout various food processing activities.

Water has numerous important aspects in the world of food science. Water's physical characteristics are influenced by solutes such as salts and carbohydrates. Solutes influence the boiling and freezing points of water. One mole of sucrose per kilogramme of water, for example, raises the boiling point of water by 0.52 degrees Celsius, while one mole of salt per kilogramme of water raises the boiling point by 1.04 degrees Celsius. Similarly, increasing the quantity of dissolved particles reduces the freezing point of water. Water activity is also affected by solutes in water, which impacts several chemical reactions and the growth of bacteria in food. Water activity is defined as the ratio of water vapour pressure in a solution to pure water vapour pressure. Water solutes reduce water activity. This is significant since most bacterial development stops at low levels of water activity. Microbial proliferation influences not just food safety, but also food preservation and shelf life.

Water hardness is also an important consideration in food preparation. It has a significant impact on product quality and plays a function in sanitation. The hardness of water also influences its pH balance, which is important in food processing. Hard water, for example, limits the successful creation of clear beverages. Water hardness also has an impact on sanitation; as hardness increases, its effectiveness as a sanitizer decreases.

In the food processing sector, the concept of free water as opposed to total water, including bound water, has acquired widespread recognition. Water activity has been shown to have a significant impact on phenomena such as colour, taste, and scent alteration, food poisoning and spoiling (shelf life), vitamin loss, and so on. The total moisture content of the food has very little effect on these metrics. Water activity in foods can be managed by utilising various additions (e.g., salts, sugars, etc.), good packaging materials, and good storage conditions. Water activity assessments are becoming more used in food research and quality control facilities.

<u>The Importance of Water Activity in Foods</u>-

The importance of water activity in foods is illustrated by the following few examples:

1- **Growth of Microorganisms**: Water activity denotes the amount of water available to microorganisms in the total water content of the food. Each microorganism (bacteria, yeast, and mould) has its own minimum water activity value below which growth is impossible. Water activity is particularly effective in forecasting the growth of bacteria, yeasts, and moulds. Controlling either the acidity level (pH) or the amount of water activity, or an appropriate combination of the two, is required for a food to have an acceptable shelf life without relying on refrigerated storage. This can significantly improve product stability and allow for the prediction of shelf life under known ambient storage conditions. Food can be made safe to store by reducing the water activity to a level where harmful organisms like Clostridium botulinum and Staphylococcus aureus cannot grow. Water activity levels can support the growth of specific kinds of bacteria, yeasts, and moulds.

Example- Food with a water activity of less than 0.6 will not allow the growth of osmophilic yeasts, which might be an issue in high sugar goods. Clostridium botulinum, the most hazardous food poisoning bacterium, cannot grow in water with an activity of 0.93 or below. Food poisoning should be avoided while eating low acid meals (pH > 4.5) with a water activity greater than 0.86. Staphylococcus aureus, a common food poisoning pathogen, may thrive in water with this low activity level. Cheese and fermented sausages held above proper refrigeration temperatures may foster the growth of this bacterium.

<u>Chemical Stability</u>:

Controlling water activity is critical for food chemical stability. Because most foods contain carbs and proteins, they are susceptible to non-enzymatic browning reactions (Maillard reaction). The Maillard reaction becomes stronger as water activity increases, reaching its maximum at 0.6 to 0.7. This reaction becomes rapidly weaker as water activity increases. Water activity has a strong influence on the spontaneous autocatalytic breakdown of fat molecule chains. This type of food deterioration becomes more prevalent at high water activity levels. Foods with a high fat content, even at low water activity levels, develop a rancid taste after some time in storage. Foods that produce fatty acids with short molecular chains as a result of lipase action are particularly susceptible to this type of spoilage: they emit a strong and undesirable odour. Food conservation is influenced by several changes caused by oxidation, such as colour change of carotene, oxidation of myoglobin in meat, oxidation of proteins and vitamins, and so on. When water activity falls below 0.2, the oxidation of lipids and other dietary components drops dramatically.

<u>Enzymatic Stability</u>:

Controlling water activity is critical for food chemical stability. Because most foods contain carbs and proteins, they are susceptible to non-enzymatic browning reactions (Maillard reaction). The Maillard reaction becomes stronger as water activity increases, reaching its maximum at 0.6 to 0.7. This reaction becomes rapidly weaker as water activity increases. Water activity has a strong influence on the spontaneous autocatalytic breakdown of fat molecule chains. This type of food deterioration becomes more prevalent at high water activity levels. Foods with a high fat content, even at low water activity levels, develop a rancid taste after some time in storage. Foods that produce fatty acids with short molecular chains as a result of lipase action are particularly susceptible to this type of spoilage: they emit a strong and undesirable odour. Food conservation is influenced by several changes caused by oxidation, such as colour change of carotene, oxidation of myoglobin in meat, oxidation of proteins and vitamins, and so on. When water activity falls below 0.2, the oxidation of lipids and other dietary components drops dramatically.

1.3 LET US SUM UP

Food is fundamentally necessary for humans for energy. Nutrition refers to the mechanisms by which the foods individuals eat give the nutrients they require to grow and maintain their health. Proteins, carbs, fats, vitamins, minerals, and water are the six types of nutrition. The chemistry of these nutrients has an impact on the properties of the meal.

We covered the different properties of food in this unit, such as physical, rheological, electrical, thermal, and mass transfer, because these aspects influence all the food we eat. This section primarily disseminates knowledge and awareness about food ingredients and their relevance. Water, moisture, carbohydrates, protein, lipid, vitamins, minerals, and phytochemicals are the key food elements examined in this subject. This course elaborates on all conceivable nutritional and biochemical facts of all dietary ingredients while also discussing the importance of these nutrients in food and the human body.

1.4 KEYWORDS

Food: Foods are materials that are ingested by humans for food, sustenance, and enjoyment in their naturally occurring, processed, or prepared forms.

Lipids: A large class of fat-like compounds having comparable characteristics.

Minerals: Minerals are only required in trace amounts and serve a variety of roles in the human body.

Nutrition:	It refers to the processes by which the foods individuals eat deliver the nutrients they require to grow and maintain their health.
Nutrient Needs:	It is the bare minimum of nutrient consumption required to maintain normal functions and health.
Protein:	Long chains of amino acids form large molecules.
Properties of foods:	Food qualities include physical, rheological, electrical, thermal, and optical properties.
Triglycerides:	A neutral fat molecule composed of three fatty acids connected to one glycerol molecule by a specific chemical bond known as ester.
Vitamins:	Vitamins are chemical components found in food that are required in minute quantities to regulate chemical reactions in our bodies.

CHECK YOUR PROGRESS EXERCISE

1- What are the major properties of food? Define them.

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2- Write down a short note on "Chemistry of Carbohydrate and Protein".

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3- Briefly explain about the Essential Nutrients and their function for Human Health

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4- Write down a short note on “Phytochemicals”

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<u>Fill in the Blanks-</u>

1. ……………………is the basic unit of Protein.
2. The composition of Starch molecule is Amylose and …………………………
3. The lipids which are solid at room temperature known as………………………..
4. ……………vitamin known as antioxidant vitamin.

<u>State weather the statement is True or False</u>-

1. Unsaturated Fatty Acids contain only single bond.
2. All the Enzymes and Hormones are Protein.
3. Glucose is the Primary Source of the Energy.
4. Fibres are non-Digestible part of the Food.

UNIT 3: WATER AND FOOD DISPERSION

3.1. Introduction

In the previous unit, we explored the essential constituents, properties, and significance of food. We gained a deeper understanding of the vital components that make up our diet and their importance in nourishing our bodies. Now, in this unit, we will shift our focus towards water and its role in food dispersion. Water plays a crucial role in numerous biological processes, and its presence greatly influences the dispersion of food components. By studying the physical and chemical properties of water and ice, we can gain insights into how they interact with food components. This knowledge helps in understanding food processing techniques, ingredient functionality, and the overall behaviour of food systems. Knowledge of sorption phenomena, water activity, and solution properties is crucial for understanding food preservation methods and predicting food spoilage. It allows us to determine the conditions that support microbial growth, enzymatic reactions, and chemical degradation, helping us develop effective preservation strategies. The study of colloidal systems, gel formation, and rheology helps us understand the texture, stability, and mouthfeel of food products. It enables the development of desirable sensory attributes and assists in formulating products with the desired consistency and structure. Emulsions and foams are important in many food products, such as dressings, sauces, ice creams, and baked goods. Understanding their formation, stability, and the role of surfactants and emulsifiers helps in creating products with desired characteristics, such as smoothness, creaminess, and mouth-coating properties.

Therefore, in this unit we will explore the physical properties of water and ice, the chemical structure of water molecules, and the phenomenon of sorption. We will learn about the different types of water and their colligative properties. Furthermore, we will examine the concept of free and bound water activity and its relation to food spoilage. Additionally, we will study the freezing process and the structure of ice, as well as the stabilization of colloidal systems and the rheology of food dispersion. Moreover, we will delve into the structure, formation, strength, types, and permanence of gels. Lastly, we will explore the formation, stability, surfactants, and emulsifiers involved in emulsions, as well as the structure, formation, and stabilization of foams.

Objectives

You will be able to:

- Learn about the Physical properties, Chemical nature and structure of water and ice
- Comprehend the Sorption phenomena, Solution and colligative properties
- Learn about the types of water, free and bound water, water activity and food spoilage
- Understand about the Colloidal salts, gel, emulsion and foams.

Water is an indispensable constituent of food, playing a crucial role in its composition and overall functionality. It serves as the primary medium for various biological processes, ensuring proper hydration and supporting the optimal functioning of the human body. Water contributes to the moisture content of food, influencing its texture, juiciness, and sensory attributes. Additionally, it acts as a medium for heat transfer during cooking, helping to soften ingredients, dissolve flavors, and facilitate the culinary process. Water is also vital in food preservation and processing, serving as a cleaning agent and carrier for additives and preservatives. Furthermore, water participates in the development of food structure and texture, interacting with proteins, starches, and other components to create desirable viscosities and stability. Lastly, water enables the rehydration of dried food products, restoring their original texture, flavor, and nutritional value. In summary, water's presence as an essential constituent in food is vital for its sensory appeal, nutritional value, and overall quality

3.2. Physical properties of water and ice:

Water:

- When the temperature as well as pressure are normal, water is a liquid. It changes from a solid to a liquid form at a temperature of 0 degrees Celsius (32 degrees Fahrenheit), and from a liquid to a gaseous form at a temperature of 100 degrees Celsius (212 degrees Fahrenheit).
- Liquid water has a density of about 1 gram per cubic centimeter (g/cm^3) at 4 degrees Celsius (39 degrees Fahrenheit). It is at its densest at this temperature, and as it cools further, it expands and becomes less dense.
- Water can absorb and store a lot of heat energy due to its high specific heat capacity, without experiencing major temperature variations. This property makes water an efficient temperature regulator and contributes to the stability of aquatic environments and Earth's climate.
- The high heat of vaporisation of water indicates that converting it from a liquid to a gas demands a significant amount of energy. This property allows water to

effectively absorb heat during processes like evaporation, cooling, and perspiration.

Water has the capacity to dissolve a large variety of compounds, earning the tag of "universal solvent". The separation and dissolution of solutes are made possible by the bonds that hydrogen makes with other molecules that are polar or ions.

Ice:

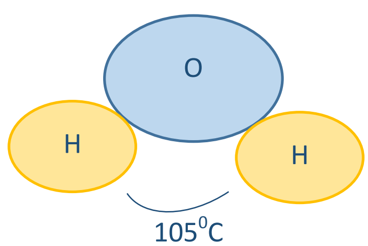
- Water exists in its solid state as ice. When water becomes liquid at temperatures below 32 degrees Fahrenheit (0 degrees Celsius). Ice is created when water molecules rearrange themselves into a crystalline framework.
- Ice floats on the water's surface because it has a lower density than liquid water. For the same volume of liquid water, ice molecules create an open lattice structure, taking up a greater amount of space.
- Unlike most substances, water expands as it freezes. This expansion can exert significant force, leading to the cracking of containers or structures if the water within them freezes.
- Ice crystals typically exhibit a hexagonal lattice structure, with water molecules arranged in a repeating pattern. This structure gives ice its characteristic shape and properties.
- Ice has a lower heat capacity compared to liquid water, meaning it requires less heat energy to raise its temperature. This property allows ice to melt at a relatively lower temperature compared to the boiling point of liquid water.

3.3. Chemical nature:

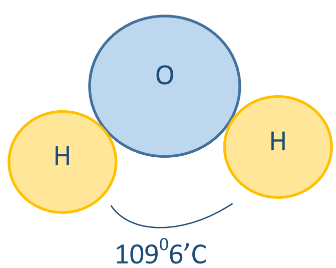
Two hydrogen (H) atoms are covalently bound to one oxygen (O) atom to produce water. It is a chemical molecule having the molecular formula H_2O. The chemical nature of water arises from its molecular structure and the bonding interactions between its atoms. The one atom of oxygen and the two atoms of hydrogen are linked to form a bent or V-shaped configuration. The bonds that exist are covalent, which means that both the oxygen atom and hydrogen atom share electrons. Since the oxygen atom has a stronger electronegativity than the hydrogen atom, the oxygen atom draws the electrons that are shared towards itself, causing the oxygen atom to have a partially negative charge (-) and the hydrogen atoms to have a partially positive charge (+).

This polarity makes the molecule of water polar, with an unequal distribution of positive and negative charges. In contrast to hydrogen atoms, which have a small positive charge, oxygen atoms are slightly negatively charged. Hydrogen bonds can be formed between water molecules because of their polarity. When one water molecule's partially positive hydrogen atom attracts the partially negative oxygen atom of another water molecule, resulting in the formation of hydrogen bonds.

These hydrogen bonds are relatively weak compared to covalent bonds but are crucial in determining many of the unique properties and behaviours of water.
The chemical nature of water as a polar molecule with hydrogen bonding gives rise to its cohesive and adhesive properties, high boiling and melting points, high specific heat capacity, and its ability to dissolve many substances. These characteristics make water an excellent solvent, a crucial component in biological processes, and a key medium for many chemical reactions.



WATER



ICE

Figure 1: Structure of water and ice

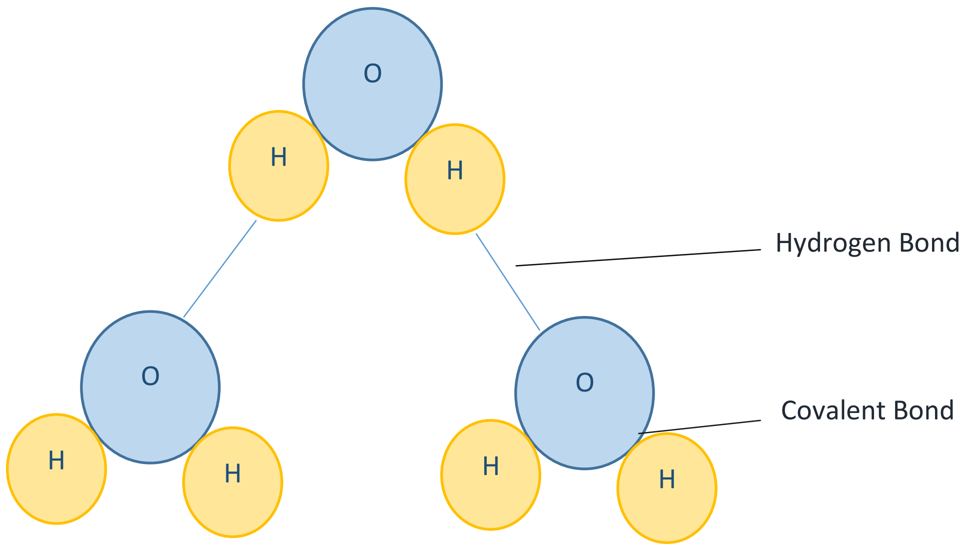


Figure 2: Different bonds of water molecule

3.4. Structure of water molecule:

The structure of water refers to the arrangement of water molecules and the bonding interactions between them. Water is a simple molecule composed of two hydrogen atoms bonded to one oxygen atom, forming a V-shaped geometry.

The key features of water's structure are:

- The oxygen atom and the two hydrogen atoms in a water molecule form covalent bonds. The sharing of electrons between atoms creates covalent bonds, which lead to the construction of stable molecular frameworks.
- Because hydrogen and oxygen have different electronegativity, water is a polar molecule. A partial negative charge (-) is created on the oxygen atom, and a partial positive charge (+) is created on the hydrogen atoms

as a result of the oxygen atom's higher electronegativity drawing the shared electrons towards it.

- The two hydrogen atoms in water are arranged asymmetrically around the oxygen atom, resulting in a bent or V-shaped molecular structure. This bent shape arises from the repulsion between electron pairs and the orientation of the hydrogen atoms.
- As a result of hydrogen bonds, molecules of water attract one another. One water molecule's oxygen atom connects with another's hydrogen atom via a hydrogen bond. The partially positive hydrogen atom and the partially negative oxygen atom magnetise to one another by electrostatic force of attraction, resulting in the formation of hydrogen bonds.
- Water molecules are not randomly arranged but rather form a tetrahedral arrangement due to the geometry of hydrogen bonding. Every water molecule has the ability to create hydrogen bonds with up to four of its neighbours, creating a web of interlinked water molecules.

The structure of water and the presence of hydrogen bonding contribute too many of its unique properties, such as high boiling and melting points, high specific heat capacity, surface tension, and its ability to act as a solvent. The arrangement and interactions between water molecules are essential for understanding water's behaviour and its role in various biological, chemical, and physical processes.

3.5. Sorption phenomena:

Sorption phenomena in water encompass the intricate processes of adsorption and absorption. Adsorption entails the adherence of substances to the surface of solid or liquid materials, such as water. It is a consequence of intermolecular forces and interactions, causing the adsorbates to bind to the adsorbent's surface. This phenomenon plays a pivotal role in water treatment, where adsorbents like activated carbon selectively attract and retain contaminants through mechanisms such as chemical bonding, electrostatic interactions, or Van der Waals forces.

Absorption, on the other hand, involves the penetration and dispersion of substances into the bulk of a material, in this case, water. It occurs when solutes permeate and disperse throughout the water volume, whether in the form of dissolved gases or solutes. For instance, the absorption of carbon dioxide into water leads to the formation of carbonic acid, influencing the water's pH and playing a significant role in the phenomenon of ocean acidification. Absorption is also relevant in scenarios like groundwater contamination, where pollutants are absorbed into the water phase and subsequently transported through subsurface aquifers.

Desorption, the reverse of adsorption, denotes the release or removal of adsorbed substances from the surface of an adsorbent or water itself. Environmental conditions, such as alterations in temperature, pH, or the presence of competing ions, can trigger desorption. Desorption processes are crucial as they govern the mobility and fate of contaminants in water environments. In soil-water systems, for example, desorption of adsorbed pollutants can result in their release into groundwater, potentially causing contamination.

Ion exchange is another noteworthy sorption phenomenon, characterized by the interchange of ions between the water phase and solid materials. Certain materials, like ion exchange resins or zeolites, possess surfaces with specific charges that attract and retain ions of opposite charge. By facilitating the exchange of ions, ion exchange processes are employed extensively in water treatment, such as the softening of water by swapping calcium and magnesium ions for sodium ions.

3.6. Free and water bound

Water that is easily retrieved or detachable from a substance or material is referred to as free water. It is water that can be isolated by physical methods like compressing, cutting, or pressing and is not tightly bound or linked with other components. In liquids or other compounds having a large amount of moisture, can often be available as free water. The term "free water" in the foods implies the water that is readily available in the food matrix. The liquid that is released when you cut a fruit, or squeeze a citrus fruit is free water. It is easily obtainable and does not require much effort to be isolated from the food.

Bound water is water that is tightly bound to other substances or macromolecules like protein, carbohydrates, or fibres and is difficult to physically separate. Bound water is difficult to separate, in contrast to free water, which is easily retrieved by squeezing or cutting. It retains its position by a variety of means, including hydrogen bonding, electrostatic interactions, and physical trapping, and it stays closely linked to the food's constituent parts. The qualities of food products are impacted by bound water. For instance, the volume as well as distribution of bound water have an impact on the flexibility, firmness, and juiciness of meat, vegetables, and fruits. Bound water can aid in preserving of moisture and the prevention of staling in baked goods.

Food dispersion: Food dispersion refers to the process of distributing and dispersing various components and ingredients within a food system. It involves achieving a homogeneous mixture and even distribution of solids, liquids, gases, flavors, and nutrients throughout the food matrix. Food dispersion is essential for ensuring uniformity in taste, texture, and nutritional content in food products.

3.7. Solution and colligative properties

A homogenous mixture made up of two or more substances is referred to as a solution. The solute and the solvent are the two primary elements of a solution. The substance that is going to be dissolved is known as the solute, and the solvent is the substance that the solute is dissolved in. Solutions can be classified into various types based on the physical states of the solute and solvent. For example, if both the solute and solvent are in the liquid state, it is a liquid-liquid solution. If the solute is a solid and the solvent is a liquid, it is a solid-liquid solution. If the solute is a gas and the solvent is a liquid, it is a gas-liquid solution. Additionally, solutions can also exist between gases and between solids.

The solute particles must be uniformly dispersed throughout the solvent particles in order develop a solution. Intermolecular interactions between the molecules of the solvent and solute cause this to happen. These interactions may be based on forces such as London dispersion forces, interactions between dipoles, or hydrogen bonding. Different qualities, including concentration, solubility, and colligative features, can be used to explain how solutions behave. The term "concentration" describes how much solute is contained in a specific amount of solvent or solution. At a specific temperature and pressure, the maximum quantity of a solute that may dissolve in a given amount of solvent is referred to as its solubility.

True solution: In a true solution, the particle size of the solute is typically on the molecular or ionic scale, meaning the particles are extremely small. The solute particles are often less than 1 nanometer (10^-9 meters) in diameter. Due to their small size, the solute particles are not visible to the naked eye and do not scatter light, resulting in a transparent solution. This small particle size allows for the solute to be uniformly dispersed and remain in a stable state within the solvent.

Colligative features describe a solution's physical characteristics that are purely dependent on the quantity of particles present, irrespective of their nature. In simple terms, colligative qualities are the characteristics of a solution that are influenced by the quantity of solute particles present rather than by the composition of those particles.

Solutions have the following four colligative characteristics:

Vapour Pressure Depression: The vapour pressure of a solution is reduced by the existence of a non-volatile solute in the solvent. This is due to the fact that the solute particles take up space on the solvent's surface, which lowers the number of solvent molecules that can exit into the gas state. Vapour pressure depression is a colligative feature as it solely depends on the solute particle concentration not its nature.

Boiling Point Elevation: The boiling point of the solution rises when a non-volatile solute is added to a solvent. This is so because the solute particles prevent the solvent from vaporising properly, demanding a greater temperature to dissipate the vapour pressure. Because it solely relies on the solute particles' concentration and not their nature.

Freezing Point Depression: A solvent's freezing point is lowered when a solute is present. It becomes more challenging for the solvent to solidify as a result of the solute particles interfering with the development of the solvent's crystal lattice framework. Due to its dependence only on the concentration of the solute particles and not their nature, freezing point depression is considered as colligative feature.

Osmotic Pressure: The amount of pressure needed to force solvent molecules from one area with low solute concentration to another with a high solute concentration through a semipermeable membrane is known as osmotic pressure. The osmotic pressure of the solution increases as solute particle concentration increases. It is regarded as colligative property as its only depend on the concentration of the solute particles and not on the nature of those particles.

3.8. Water activity and food spoilage:

Water activity (aw) is a measurement that describes the readily accessibility for growth of microbes, chemical reactions, and enzymatic activity in a food product. It is defined as the vapour pressure of water in a food sample divided by the vapour pressure of pure water at the same temperature. Water activity values range from 0 to 1, with higher values indicating more available water.

Water activity is a crucial factor in food preservation and the prevention of food spoilage. When the water activity of a food product is high (close to 1), it provides an environment conducive to microbial growth, including bacteria, yeasts, and molds. These microorganisms require available water to survive, reproduce, and cause spoilage. Therefore, controlling water activity is essential in preventing microbial spoilage in food.

By controlling water activity, food manufacturers can extend the shelf life of products and maintain their quality. Lowering the water activity can inhibit microbial growth and enzymatic reactions, thereby reducing the risk of spoilage. Several preservation techniques, such as drying, salting, and adding preservatives, aim to reduce water activity in foods.

Some microorganisms are more tolerant to low water activity conditions, such as certain molds and bacteria. They can survive and even grow at lower water activity levels. Therefore, understanding the water activity requirements of specific microorganisms is crucial for effective food preservation strategies.

Along with microbial spoilage, high water activity can trigger chemical processes like lipid oxidation and enzymatic browning that can negatively impact the nutritional value and sensory qualities of food products. Controlling water activity can help minimize these reactions and maintain the desired product characteristics. Food regulatory agencies and industry guidelines often specify water activity limits for different types of food products to ensure their safety and stability. Manufacturers routinely measure and monitor water activity to assess the potential for microbial growth and implement appropriate preservation methods.

3.9. Freezing and ice structure

When water is cooled below its freezing point, it undergoes a phase transition and transforms into ice. The freezing process involves the formation of an organized and structured arrangement of water molecules, resulting in the formation of ice crystals.

The arrangement of water molecules gives ice its distinctive shape. Ice is a solid form of water. Each water molecule contains two hydrogen atoms and one oxygen atom that are linked by a covalent bond. Water molecules are always moving and are loosely attached to each other. However, during freezing, the water molecules slow down and come together, forming a more rigid and ordered structure.

The most common form of ice is known as ice, which is the stable hexagonal crystal lattice structure. Each water molecule in this arrangement forms a three-dimensional network through hydrogen bonds with four of its neighbours. Ice's distinctive six-fold symmetry is due to the water molecules' hexagonal configuration.

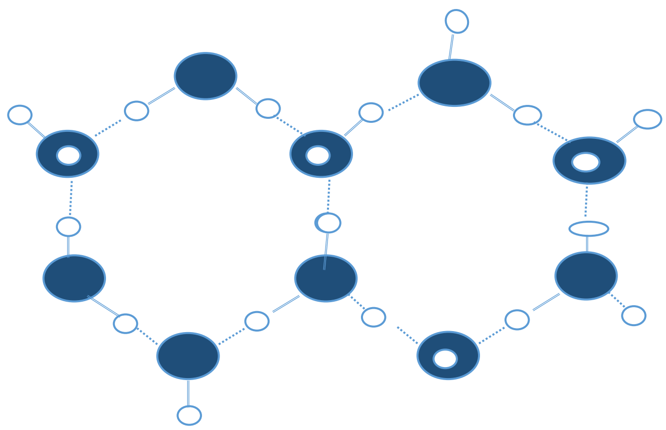


Figure 3: Structure of ice crystal

The hydrogen bonds between water molecules in ice are responsible for its unique properties. These hydrogen bonds hold the water molecules in a fixed position, creating a stable and rigid structure. This is why ice is less dense than liquid water, as the hydrogen bonds in the crystal lattice cause the water molecules to be more spaced out. Ice crystals can vary in size and shape depending on factors such as the rate of freezing and the presence of impurities. Slow freezing allows for the growth of larger ice crystals, while rapid freezing can lead to the formation of smaller crystals.

3.10. Colloidal salts

Colloidal salts refer to salts that are in a colloidal state, meaning they exist as colloidal particles dispersed in a medium (usually a liquid) without completely dissolving. Colloidal particles are larger than individual ions or molecules but smaller than visible particles, typically ranging in size from 1 to 1000 nanometers.

When a salt is in a colloidal state, the salt particles are dispersed throughout the medium, forming a stable colloidal suspension. The salt particles have a net electric charge, which helps to repel each other and prevent their aggregation or settling.

Colloidal salts can be formed through various processes, such as the controlled precipitation of salts under specific conditions or the dispersion of finely ground salts in a liquid medium.

3.10.1. Stabilization of colloidal system

The choice of the medium and the conditions of formation play a crucial role in achieving colloidal stability.

Colloidal salts have unique properties due to their colloidal nature. These properties include:

Particle Size: Colloidal salts have a relatively small particle size, which allows them to remain dispersed and suspended in a medium for an extended period. The small particle size also contributes to their large surface area, which can impact their reactivity and interactions with other substances.

Stability: Colloidal salts exhibit stability due to the repulsive forces between the charged particles. This stability prevents the particles from agglomerating or settling, maintaining the colloidal suspension over time.

Optical Properties: Colloidal salts can exhibit unique optical properties, such as the Tyndall effect. When light passes through a colloidal suspension, the dispersed particles scatter the light, making the suspension appear hazy or milky.

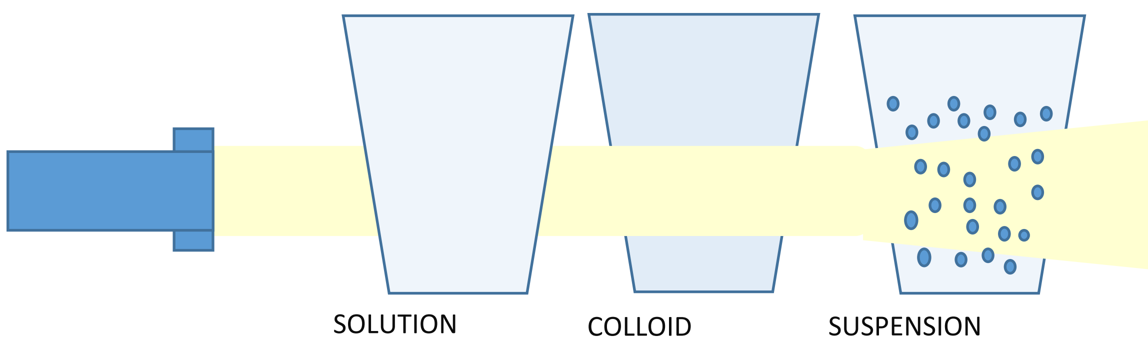


Figure 4: Tyndall effect

Reactivity: Colloidal salts may display different reactivity compared to their fully dissolved counterparts. The larger surface area and the interaction between the charged particles and the medium can influence their chemical behavior and potential applications.

3.10.2. Rheology of food dispersion:

The rheology of food dispersions refers to the study of how food materials behave under applied forces, such as shear or deformation, when they are in a dispersed or particulate form. It involves understanding the flow and deformation characteristics of food dispersions, including their viscosity, elasticity, and other rheological properties.

Food dispersions encompass a wide range of products, including emulsions (such as salad dressings or mayonnaise), suspensions (such as fruit juices with pulp), and foams (such as whipped cream). Each type of dispersion exhibits its own unique rheological behavior due to the specific arrangement and interaction of the dispersed particles within the continuous phase.

Rheological properties play a crucial role in determining the sensory attributes, stability, processing, and quality of food dispersions. Here are some key rheological properties and phenomena associated with food dispersions.

Viscosity: Viscosity refers to the resistance of a fluid to flow. In food dispersions, viscosity determines the thickness or fluidity of the product. It affects attributes such as mouthfeel, texture, and spreadability. The viscosity of a dispersion can be influenced by factors such as particle size, concentration, particle interactions, and temperature.

Shear-Thinning and Shear-Thickening: Many food dispersions exhibit non-Newtonian behavior, meaning their viscosity changes with the applied shear rate. Shear-thinning behavior is observed when the viscosity decreases as shear rate increases (e.g., tomato ketchup). Shear-thickening behavior occurs when the viscosity increases with shear rate (e.g., some starch-based suspensions).

Yield Stress: Yield stress refers to the minimum amount of stress required to initiate flow in a material. Some food dispersions, such as gels or pastes, exhibit a yield stress, meaning they behave as solid-like materials until a certain stress threshold is reached. Examples include yogurt or mayonnaise.

Elasticity: Elasticity refers to the ability of a material to deform and then return to its original shape when the applied force is removed. Some food dispersions, like foams or certain gels, possess elastic properties. The elasticity can affect the stability, structure, and mouthfeel of the food product.

Thixotropy: Thixotropy is a time-dependent shear thinning behaviour observed in some food dispersions. These dispersions show a decrease in viscosity over time when subjected to continuous shear, but the viscosity recovers when shear is removed. Thixotropic behaviour is common in certain sauces or dressings.

3.11. Gel

Gel structure refers to the framework or network of interconnected solid-like structures that form within a gel. Gels are semi-solid materials composed of a liquid trapped within a three-dimensional matrix. The structure and strength of a gel depend on the specific gel-forming material and the conditions under which it forms.

Gel formation occurs through a process known as gelation, which involves the transformation of a sol (a dispersed phase in a liquid) into a gel (a continuous network). The structure and strength of a gel depend on various factors, including the nature of the gelatinous material and the conditions under which gelation occurs.

Gels can be classified into chemical gels and physical gels.

Chemical Gels: Chemical gels form through the chemical reaction of molecules, resulting in the cross-linking or polymerization of the gel-forming material. For example, gelatin gels form when gelatin proteins undergo denaturation and subsequent reassociation to form a three-dimensional network.

Physical Gels: Physical gels form through non-covalent interactions, such as hydrogen bonding, electrostatic forces, or physical entanglement of polymer chains. These gels rely on reversible interactions and can be formed by cooling, evaporation, or addition of suitable agents. Examples include agar or alginate gels.

Gels can exhibit varying strengths depending on the extent and nature of the network formed:

Weak Gels: Weak gels have a loose or fragile structure with relatively low resistance to deformation. They may exhibit low viscosity under low stress conditions but can undergo flow or collapse under applied shear or stress.

Strong Gels: Strong gels have a more robust and tightly connected network, offering higher resistance to deformation. They typically exhibit higher viscosity or firmness and maintain their structure even under significant stress.

The permanence of a gel refers to its stability over time. Some gels are reversible, meaning they can be transformed back into a sol or a liquid-like state under suitable conditions, while others are permanent or irreversible gels that maintain their structure indefinitely.

The permanence of a gel depends on factors such as the strength of the gel network, the presence of stabilizers, and external conditions like temperature, pH, or mechanical stress. Some gels, like those formed by physical interactions, can be easily disrupted and revert to a sol state when the conditions change (e.g., heating or dilution). Other gels, such as chemically cross-linked gels, are more stable and maintain their structure even under varying conditions.

3.12. Emulsion: formation

An emulsion is a type of colloidal dispersion in which two immiscible liquids are dispersed in each other. Typically, an emulsion consists of two phases: the dispersed phase and the continuous phase. The dispersed phase is composed of small droplets or globules of one liquid dispersed throughout the continuous phase.

The two common types of emulsions are oil-in-water (O/W) and water-in-oil (W/O) emulsions, depending on whether the continuous phase is water or oil, respectively.

In an oil-in-water emulsion (O/W), tiny droplets of oil are dispersed within a continuous phase of water. Examples of O/W emulsions include milk, salad dressings, and most lotions. In this type of emulsion, an emulsifier is typically used to reduce the interfacial tension between the oil and water phases, allowing the oil droplets to remain dispersed and preventing them from coalescing.

On the other hand, in a water-in-oil emulsion (W/O), small droplets of water are dispersed within a continuous phase of oil. Examples of W/O emulsions include butter and margarine. Emulsifiers, such as mono- and diglycerides, are used to stabilize the emulsion and prevent the water droplets from merging.

Emulsions can have a wide range of applications in various industries, including food, cosmetics, pharmaceuticals, and paints. They are used to create desirable textures, improve flavor release, enhance stability, and facilitate the delivery of active ingredients.

3.12.1. Emulsifier

Emulsifiers have two distinct parts: a hydrophilic (water-loving) head and a hydrophobic (water-hating) tail. The hydrophilic head is attracted to water, while the hydrophobic tail is attracted to oil. When added to an oil-water mixture, emulsifiers position themselves at the oil-water interface, with their hydrophilic heads in the water phase and their hydrophobic tails in the oil phase. This arrangement forms a protective layer around the oil droplets, preventing their coalescence and maintaining the stability of the emulsion.

3.12.2. Stability

The stability of an emulsion is determined by the balance between various forces. The main forces at play are:

Interfacial Tension: Emulsifiers reduce the interfacial tension between oil and water, preventing the droplets from coalescing and separating. Lower interfacial tension contributes to greater stability.

Steric Hindrance: Emulsifiers form a protective layer around the oil droplets, creating steric hindrance that impedes droplet coalescence. This hindrance is due to the physical presence of the emulsifier molecules at the interface.

Electrostatic Repulsion: Some emulsifiers carry an electrical charge, which leads to electrostatic repulsion between oil droplets. The repulsive forces hinder droplet aggregation and enhance emulsion stability.

Stability: Choosing the appropriate emulsifier is essential for achieving and maintaining emulsion stability. Different emulsifiers have varying degrees of effectiveness depending on the specific oil and water phases involved. Factors such as the emulsifier concentration, type of emulsifier, pH, temperature, and mixing techniques also influence emulsion stability.

Surfactant: Surfactants, which are a type of emulsifier, play a vital role in emulsion formation and stability. They reduce surface tension between immiscible phases and help disperse one liquid phase into smaller droplets within the other phase. Surfactants have hydrophilic and hydrophobic regions, enabling them to interact with both oil and water phases, thereby stabilizing the emulsion.

Common examples of emulsifiers include:

Lecithin: Extracted from sources like soybeans or egg yolks, lecithin is a natural emulsifier commonly used in food and cosmetic products.

Mono- and Diglycerides: These are fatty acid esters of glycerol and act as emulsifiers in various food products, such as baked goods and dairy items.

Polysorbates: Polysorbates, such as Polysorbate 80, are synthetic emulsifiers used in food, pharmaceuticals, and cosmetics to stabilize emulsions and improve texture.

Sodium Stearoyl Lactylate (SSL): SSL is a food-grade emulsifier that helps stabilize emulsions and improve dough properties in baked goods.

Sorbitan Esters (Span): Sorbitan esters, also known as Spans, are widely used as emulsifiers in the food and cosmetic industries.

3.13. Foams

Foams are dispersions consisting of gas bubbles dispersed within a liquid or solid matrix. They are encountered in various food and beverage products like whipped cream, meringues, and carbonated beverages. The structure and stability of foams are determined by the processes of foam formation and stabilization.

Foam formation begins with the incorporation of gas bubbles into a liquid or solid matrix. This can occur through mechanical agitation, such as whisking or mixing, or through the release of gas during fermentation or chemical reactions. The gas bubbles become dispersed within the continuous phase, and their size and distribution play a significant role in foam properties.

Stabilization: The stabilization of foams is crucial to prevent the coalescence and collapse of gas bubbles. Stabilization is achieved through the interaction of various components, including:

Surfactants: Surfactants play a key role in foam stabilization. They are molecules with hydrophilic (water-loving) and hydrophobic (water-hating) regions. Surfactants concentrate at the gas-liquid interface, where their hydrophilic ends interact with the liquid phase, while their hydrophobic ends align towards the gas phase. This arrangement creates a surface film that reduces surface tension and inhibits bubble coalescence.

Proteins: In many food systems, proteins act as natural surfactants and contribute to foam stability. Proteins unfold and adsorb at the gas-liquid interface, forming a protective film that stabilizes the foam. The type and concentration of proteins influence the foam structure and stability.

Polysaccharides: Certain polysaccharides, such as gums and stabilizers, can enhance foam stability. They contribute to viscosity, create a network within the liquid phase, and help trap and stabilize gas bubbles.

Mechanical Factors: Mixing or whipping the foam can also contribute to its stability. Mechanical agitation incorporates air into the system, promotes bubble distribution, and creates a network of gas bubbles. It can also disrupt large bubbles and promote the formation of smaller, more stable bubbles.

Foam stability can be affected by various factors, including temperature, pH, concentration of stabilizers, and the presence of other ingredients. Over time, foams may lose stability due to bubble coalescence and drainage, where liquid drains from the foam structure.

3.14. LET US SUM UP

In food science, colligative properties are significant because they affect the texture, stability, and shelf-life of food products. For example, the freezing point depression of ice cream mixtures due to the addition of sugar or other solutes affects the texture and creaminess of the final product. Similarly, the osmotic pressure of a brine solution in pickling affects the texture.

Water activity is a critical parameter in food preservation. By controlling water activity, food manufacturers can prevent microbial spoilage, extend shelf life, and maintain the quality and safety of food products. Understanding the relationship between water activity and food spoilage is essential for developing effective preservation strategies in the food industry. The rheology of food dispersions helps in product formulation, processing optimization, and quality control. It enables manufacturers to achieve desired textural attributes, control product stability, and ensure proper handling and flow properties. Rheological measurements and modeling techniques, such as viscosity measurements, creep testing, or oscillatory rheology, are used to characterize and analyze the rheological properties of food dispersions. The gel structure, formation, strength, and permanence is crucial in various industries, including food, cosmetics, and pharmaceuticals. It helps in the development of products with desired textures, stability, and functional properties, allowing for the creation of a wide range of gel-based formulations.

Emulsions are formed and stabilized by emulsifiers or surfactants. These molecules reduce interfacial tension, create a protective layer, and promote stability by preventing droplet coalescence. The choice of emulsifier and other formulation parameters are crucial in achieving and maintaining stable emulsions with desired properties. Foam structure and stabilization is essential in the formulation and processing of food products. By selecting appropriate ingredients, controlling processing conditions, and incorporating stabilizers, manufacturers can achieve and maintain desirable foam structures and enhance the sensory and textural attributes of their products.

3.15. Glossary

Solvent: A substance capable of dissolving other substances to form a solution. In food dispersion, water is often referred to as the universal solvent due to its ability to dissolve a wide range of solutes.

Hydration: The process of water molecules binding to other molecules, promoting softening and improved digestibility in food ingredients.

Emulsification: The dispersion of immiscible liquids, such as oil and water, through the use of emulsifying agents or techniques to create stable emulsions. Emulsions enhance texture, mouthfeel, and flavor in various food products.

Homogeneous Mixture: A uniform mixture where the components are evenly distributed at a molecular or particle level. In food dispersion, achieving a homogeneous mixture is important for consistent product quality.

Stabilization: The process of preventing ingredient separation and maintaining the homogeneity and texture of food dispersions. Stabilizers, such as emulsifiers, hydrocolloids, and proteins, help achieve stability in food systems.

Rheology: The study of the flow and deformation of matter. In food dispersion, rheological properties, such as viscosity, elasticity, and yield stress, influence the texture and mouthfeel of food products.

True Solution: A homogeneous mixture at a molecular or ionic level, where solute particles are uniformly dispersed and

	individually surrounded by solvent molecules. True solutions do not scatter light and do not settle over time.
Colloidal System:	A type of dispersion where microscopic particles, called colloids, are dispersed within a continuous medium. Colloidal particles range in size from approximately 1 nanometer to 1 micrometer and exhibit unique properties due to their size and surface characteristics.
Emulsifier:	An ingredient or compound that helps stabilize emulsions by reducing the interfacial tension between immiscible liquids, allowing them to remain dispersed in a stable form.
Gel:	A colloidal dispersion where the continuous medium forms a three-dimensional network, trapping dispersed particles and creating a solid-like structure. Gels have a semi-solid consistency.
Aerosol:	A colloidal dispersion where solid or liquid particles are dispersed within a gas medium, such as mist, fog, or smoke.
Brownian Motion:	The random motion exhibited by colloidal particles due to collisions with molecules in the continuous medium. Brownian motion helps keep colloidal particles evenly dispersed and prevents their settling.
Suspensions:	Heterogeneous mixtures where solid particles are dispersed within a liquid medium but tend to settle over time. Unlike colloidal systems, suspensions exhibit visible settling and may scatter light.

3.16. CHECK YOUR PROGRESS EXERCISE

Fill in the blanks:

a) ……………….is characterized by the interchange of ions between the water phase and solid materials.
b) Water is referred to as the …………………. due to its ability to dissolve a wide range of substances.
c) …………………..is water that is tightly bound to other substances or macromolecules like protein, carbohydrates, or fibres and is difficult to physically separate.
d) Water has a high ……………………..indicating that it requires a substantial amount of energy to transition from a liquid to a gas phase
e) Colloidal particles are larger than individual ions or molecules but smaller than visible particles, typically ranging in size from…………………….
f) In ………………. light passes through a colloidal suspension, the dispersed particles scatter the light, making the suspension appear hazy or milky.
g) ………………..is a time-dependent shear thinning behaviour in some food dispersions.
h) ……………. is a natural emulsifier extracted from sources like egg yolks.

Short answer type question:

1. Briefly explain the structure of water.

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2. State the physical property of water and ice.

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3. Define the following terms:

   a) Absorption

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   b) Desorption

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4. How the water activity affects the food spoilage?

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5. State the colligative properties of solutions.

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6. Discuss the structure of ice.

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7. Discuss different types of gel.

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8. Name the forces that play a major role in emulsion stability.

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9. How can the stabilization of foam can achieve?

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10. Define the following terms:

c) Surfactant………………………………………………………………
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d) Emulsifier………………………………………………………………
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3.17. Answer key

a) Ion exchange
b) universal solvent
c) Bound water
d) heat of vaporization
e) 1 to 1000 nanometers
f) Tyndall effect
g) Thixotropy
h) Lecithin

BLOCK-2 POLYSACCHARIDES, SUGARS AND SWEETENERS, CEREAL AND OIL PRODUCTS

The first by products of photosynthesis in plants are carbohydrates. More than half of the organic material on Earth is made up of these compounds in one way or another. The tissues of plants, animals, and microorganisms all contain different types and amounts of carbohydrates. Along with oils and fats, they constitute the main source of energy for the human body. Monosaccharides and oligosaccharides are abundant in plants. The main carbohydrate found in grains and root vegetables is starch. Cellulose, hemicellulose, and pectin are the "bricks" or structural carbohydrates of plants. The body's primary energy sources are lipids and carbohydrates. Various changes take place while food is being prepared. Both plant and animal sources contain lipids. During the production and storage of food, they also go through physical and chemical changes. Therefore, knowledge of these molecules' physical and chemical characteristics is essential for food preservation. Students will learn about the numerous facets of carbohydrates and lipids in this block.

Unit- 4 focuses on **'Sugars, Sweeteners, and Polysaccharides'**. The many types of polysaccharides, including starch and non-starch polysaccharides, sugars and sweeteners, and their respective food processing techniques, are discussed in detail in this unit.

Unit-5 contains information related to "**Cereals & Cereal Products**." The structure and make-up of cereal and items made from cereal are broken down and discussed in this section. This course helps students build a greater understanding of the various cereal products available, such as puffed and flaked cereals, morning cereals, and more.

Unit-6 includes "**Fats, oils, and associated Products**" in its scope of coverage. In this lesson, we will discuss the origins of fats and oils, their makeup, and the effect that their composition has on the fat's qualities. This unit also helps make it easier to understand facts regarding the breakdown of fat and antioxidants.

UNIT-1 POLYSACCHARIDES, SUGARS AND SWEETENERS

Structure-

1.0 OBJECTIVE

After reading this unit, Students will be able to-

1. Define Starch and Non-Starch Molecules
2. Explain the structural components and, properties, the functionality of starches in our food
3. Discuss the role of modified starches in the food industry and in-home use
4. Understand the chemistry and significance of Sugars and Sweeteners
5. Describe the basic chemistry behind different food-related mechanisms like fermentation

4.1 INTRODUCTION TO POLYSACCHARIDES

The majority of food polysaccharides are made from starch, while the rest are referred to as non-starch polysaccharides (NSPs). The availability of starch, a natural polysaccharide, is second only to that of cellulose, making it the primary source of food carbohydrates worldwide. This places starch in a special position. Although the majority is consumed along with the accompanying nutritious material in the form of protein, fat, fibre, and minerals, the amount isolated in a pure form is significantly greater than that of all other NSPs. Although polysaccharides typically appear in complicated mixes, the molecular structures of dietary polysaccharides, which are typically derived from plant sources, are well understood.

Polysaccharides are polymers made up of ten or more monosaccharide molecules. These monosaccharide units are connected by glycosylated bonds. While hetero-polysaccharides have two or more types of monosaccharide units, homo-polysaccharides contain just one type of monosaccharide unit. Some polysaccharides are made up of sugar derivatives, such as the monosaccharide glucosamine, a derivative of glucose, which is a repeating monosaccharide found in chitin. Different polysaccharides can be distinguished from one another by their kind of repeating monosaccharide unit, quantity of repeating units, degree of branching, and type of glycosidic connection between the monomeric units.

Homo-polysaccharides can be further divided into storage polysaccharides and structural polysaccharides based on the functional roles they play. Storage polysaccharides are used to store fuel-grade monosaccharides. Plants such as starch and animals such as glycogen are examples of storing polysaccharides. Structural polysaccharides like cellulose and chitin serve as structural elements in the cell walls of plants and animals, respectively. Homo-polysaccharides do not support life extracellularly; hetero-polysaccharides do. Hetero-polysaccharides build a matrix in the extracellular space of animal tissues that holds individual cells together and gives the cells and tissues form, support, and defence.

4.1.1- <u>Homo-polysaccharides</u>- In the process of hydrolysis, homo-polysaccharides break down into a single type of monosaccharide. They function not only as structural polymers but also as storage polymers (such as cellulose, chitin, xylan, and pectin) for example, starch, glycogen, dextran, and inulin. Table 1 provides an overview of the structures and characteristics of a selection of homo-polysaccharides.

Table-1- Structures and properties of some Homo-polysaccharides

Name	Constituent Monosaccharide	Size (No. of Monosaccharide Residue)	Biological Significance
Starch	α-D-glucose	50-5000	Energy storage in plants
Glycogen	α-D-glucose	Upto 50000	Energy storage in both animals and bacteria
Cellulose	β-D-glucose	Up to 15000	Structural role: give the cell wall stiffness and strength.
Chitin	N-acetyl-Dglucosamine	Very large	Structural role: supply insects' exoskeletons

			with rigidity and strength.
Dextran	α-D-glucose	Wide range	Structural: Bacterial extracellular adhesive
Inulin	β-D-fructose	30-35	Storage of energy in plants
Pectin	α-D-galacturonic acid		Structural: binds together cellulose fibrils in plant cell walls
Xylan	β-D-xylose	30-100	Storage and auxiliary functions in plants

4.1.2- Hetero-polysaccharides-

Hydrolysis of heteropolysaccharides results in a variety of monosaccharides. They can be found in plant, animal, and bacterial extracellular matrix.

a) Agar-

In the cell walls of marine red algae like Gelidium, Gracilaria, and Gigartina, a gelatinous polymer called agar is present. It is a sulphated heteropolysaccharide mixture made up of ether-linked D- and L-galactose derivatives between C3 and C6. The agar component with the fewest charged groups is agarose (sulfates, pyruvates). In hot water, agar and agarose dissolve to form a sol that cools to form a gel. Agarose gels are employed as an inert support in the electrophoretic separation of nucleic acids. Agar is used as a surface for the growth of bacterial and plant tissue cultures.

b) Peptidoglycan-

The bacterial cell wall contains a hard substance called peptiddoglycan. It is a heteropolysaccharide made up of alternating residues of N-acetyl-D-glucosamine and N-acetyl muramic acid that are (1(4) linked. N-acetyl muramic acid links the brief peptides that join the linear polysaccharide chains. A strong sheath that surrounds the entire cell and prevents osmotic rupture is created when peptide cross-links the polysaccharide chains together. By hydrolyzing the peptidoglycan's α-(1→4)-D glycosidic bonds, the enzyme lysozyme, which is present in human tears, destroys bacteria.

4.2 INTRODUCTION TO STARCH

Starch, commonly referred to as Amylum, is a polymeric carbohydrate comprised of many glucose units connected by α-(1→4)-D glycosidic bonds. The majority of green plants produce this polysaccharide to store energy. It is the most prevalent carbohydrate in human diets and is plentiful in staple foods like wheat, potatoes, maize (corn), rice, and cassava (manioc).

Pure starch is an odourless, tasteless, white powder that is insoluble in cold water and alcohol. It is composed of linear and helical amylose and branched amylopectin. Depending on the plant, starch contains 20 to 25 percent amylose and 75 to 80 percent amylopectin by weight. Glycogen, the energy store of an organism, is a highly branched version of amylopectin.

In industry, starch is routinely converted into sugars, for instance by malting. These sugars can be fermented into ethanol, which can be used to generate beer, whisky, and biofuel. Moreover, numerous processed foods contain sugars generated from processed starch.

4.2.1- Structure of Starch

Starch is a polysaccharide composed of a long chain of glucose molecules. There are two kinds of glucose chains in starch. The first is a simple chain called amylose, while the second is a complex branching version called amylopectin.

Starch granules are often made up of amylose (20-30%) and/or amylopectin (70-80%) molecules spread radially. Each granule typically contains several million amylopectin molecules, each of which is made up of several million glucose units, as well as a far greater number of smaller amylose molecules, each of which is made up of 500 to 20,000 glucose units in each chain. Amylopectin, which is responsible for granule formation, is a fundamental component of most starches. Amylopectin (without amylose) can be removed from 'waxy' maize starch (so named because the new surface of the kernel appears vitreous or waxy when cut), whereas amylose (without amylopectin) is best isolated after hydrolyzing the amylopectin with pullulanase specifically.

A. <u>Amylose</u>

Amylose molecules range in molecular weight from 104 to 206. Amylose can take on a variety of shapes (hydrodynamic radius 7-22 nm), It does, however, create a stiff left-handed single helix or even stiffer parallel left-handed double helical junction zones. The helix's centre is lipophilic and contains just hydrogen atoms, whereas the hydroxyl groups are found on the coil's surface. Most starches include approximately 25% amylose. The apparent amylose levels of two commercially available high amylose corn starches are around 52 percent and 70-75 percent.

B. <u>Amylopectin</u>

Amylopectin has a branching structure with around 30 glucose units in a chain connecting the branches. 'Outer' unbranched chains (also known as A-chains) are more common than 'inner' branched chains (called B-chains). The solitary reducing group is contained in only one chain (referred to as the C-chain). Each amylopectin molecule contains up to two million glucose residues in a tight shape. Amylopectin's branching structure gives it a striped appearance, with knotted branch points in a row and smooth chains separating them. Because these molecules are so large, they appear stripped under a light microscope, causing "growth rings" in the starch grain.

4.2.2- <u>Functional Properties of Starch-</u>

The majority of the calories that are contained in grains, tubers, and the foods that are created from them come from starch. However, when starch is added to products as an ingredient, it is usually the functional capabilities of the starch that are important, not the calories that are contributed to the product. Due to their adaptability and low cost, starches find use in an extremely wide variety of food applications. Clouding, Adhesives, bindings, dusting, glazing, moisture holding, stabilising, texturizing, film forming, foam strengthening, anti-staling, gelling, and thickening are just a few of the applications.

a) Starch as Thickening Agent- The primary component that causes a thickening in puddings, gravies, and sauces is starch. When starch is boiled, it transforms into a gel after absorbing water. The formation of the gel is caused by amylopectin, which is produced as the starch expands under the influence of water. Some starches have a larger amylopectin concentration than others, and as a result, they produce superior gels to those that have a significant amount of amylose. When compared to a starch solution with the same concentration, a higher amylose content results in a lower swelling power and a lower gel strength. Amylose is the component that is primarily responsible for the thickening effect.

b) Starch as a Binder, Fillers and Fat Substitute - The long water-soluble chains increase viscosity, which is not affected by temperature. Amylose chains create helices (spirals) when they coil up, with the hydrophobic regions on the inside. This allows them to trap lipid (oil and fat) and aroma molecules inside the helix. Because starches are so good at absorbing water and bulking/swelling up, they play an important role in the "mouth feel" of many food products.

The swelling power is calculated after heating the starch in excess water as the ratio of the wet weight of the sedimented gel formed to its dry weight. It is affected by processing parameters such as temperature, time, stirring, and centrifugation and can be thought of as its water binding capabilities.

The substantial but relatively poor water-binding capability of starches helps give foods structure and mouthfeel. In processed meat, starches serve as a filler, binder, moisture retainer, and fat substitute (hot dogs, sausages, etc.). Extruded cereals, ready-to-eat morning cereals, and snacks all employ them to keep their form.

c) Starch as Bulking Agent and Prebiotics- It is difficult to calculate what percentage of dietary starch is resistant to digestion in the stomach and small intestine since it varies so much depending on factors such as the kind of starch and the method of boiling it before consumption. Resistant starch, which is the sum of all starch and the byproducts of starch breakdown that are not absorbed by the small intestine of healthy people, is a type of dietary fibre that can be used to relieve constipation. By delaying the rate at which food leaves the stomach, resistant starch is useful for dieters. It plays a number of crucial physiological activities, including providing substrate for the intestinal microorganisms that generate vitamins (and intestinal gas).

4.2.3- Starch Gelatinization and Retrogradation

A. Starch Gelatinization-

When exposed to warm water, starch continues to swell until it reaches the gelatinization temperature, at which point it begins to lose its structure and spill out its eight constituents. Gelatinization describes the process through which anything transforms into a substance similar to jelly. Gelatinization is a process that takes place when heat and moisture are present in the environment at the same time. When cooked to a temperature of 1000 degrees Celsius, starch loses its ability to form H-bonds, which results in the granule expanding and the constituent starch polymers being more soluble. The viscosity of the solution increases, it gets less opaque, and it ultimately transforms into a paste. The term "gelatinization" refers to this particular procedure.

The gelatinization process involves the absorption of water, which causes the starch granule to experience an irreversible expansion to several times its original size. When starch is cooked with excess water, the molecular order of the granule is gradually and irrevocably destroyed at the gelatinisation temperature, which for most starches is in the range of 60-70°C. Amylose is preferentially leached out of the network and solubilized; however, some amylose leaching can occur prior to gelatinization as well. This is because amylose is soluble in water. When the temperature is raised to a high enough level, the granules of starch are shattered, and only a portion of the starch is dissolved.

Gelatinization in its entirety often takes place over a temperature range, with gelatinization of bigger granules typically occurring first. True molecular solution cannot be attained at temperatures lower than 100 degrees Celsius, and the swollen, hydrated granules that are predominantly composed of amylopectin continue to be present. Continued heating of starch granules in excess water promotes granule swelling, increased leaching of soluble components (mostly amylose), and eventually complete granule disruption, especially when shear pressures are applied. As a result of this process, a starch paste is formed.

B. <u>Starch Retrogradation</u>:

Starch is insoluble in cold water, but when it is exposed to warm water, it begins to swell until it reaches its gelatinization temperature, at which point it begins to lose its structure and leak out its eight constituents. Gelatinization describes the process through which anything transforms into a substance similar to jelly. Gelatinization is a process that takes place when heat and moisture are present in the environment at the same time. When cooked to a temperature of 1000 degrees Celsius, starch loses its ability to form H-bonds, which results in the granule expanding and the constituent starch polymers being more soluble. The viscosity of the solution increases, it gets less opaque, and it ultimately transforms into a paste. The term "gelatinization" refers to this particular procedure.

The absorption of water during the gelatinization process leads the starch granule to expand irreversibly to several times its original size. When starch is cooked with excess water, the molecular order of the granule is gradually and irrevocably destroyed at the gelatinisation temperature, which for most starches is in the range of 60-70°C. Amylose is preferentially leached out of the network and solubilized; however, some amylose leaching can occur prior to gelatinization as well. This is due to the fact that amylose is water soluble. When the temperature is elevated sufficiently, the starch granules fracture and only a fraction of the starch dissolves.

Gelatinization normally occurs over a temperature range, with larger granules gelatinizing first. True molecular solution cannot be achieved at temperatures below 100 degrees Celsius, and swollen, hydrated granules largely made of amylopectin remain present. Continued heating of starch granules in excess water promotes further granule swelling, increased leaching of soluble components (mostly amylose), and eventually complete granule disruption, especially when shear pressures are applied. This technique yields a starch paste.

4.3 INTRODUCTION TO NON-STARCH POLYSACCHARIDES

Carbohydrate fractions that do not include starch or free sugars are referred to as non-starch polysaccharides, or NSPs. These are a type of polymeric carbohydrates that are distinct from amylase and amylopectin in both their content and their structure. They are the structural analogues of the animal kingdom's skeletal system that can be found in the plant kingdom. NSPs are high-molecular-weight polymers composed of -linked chains of pentoses and hexoses, with molecular weights ranging from 80,000 to one million. NSPs constitute the majority of cell wall polysaccharides and have close relationships with other polysaccharides and non-carbohydrate components such as protein and lignin.

The macromolecules pectins, cellulose, hemicellulose, and oligosaccharides are all included in NSP (such as alpha-galactosidase, etc.). The key components that combine to form dietary fibre are NSPs and lignin. NSP is made up of macromolecular polymers of monosaccharides that are bound together via a type of linkage known as a glycosidic bond. When the hemiacetal group of one sugar interacts with the hydroxyl group of another sugar, this connection is formed. NSPs can be found within and outside of cells, however the most majority are generated from the cell wall. It cannot be hydrolyzed by the enzymes found naturally in the body. Xylans, arabinoxylans (pentosans), beta-glucan, and cellulose are the most common non-starch polysaccharides (NSP) found in cereal grains.

4.3.1- Classification of Non-Starch Polysaccharides

a) Based on Solubility-

- **Cellulose** –Insoluble in water, alkali or dilute acids.

- **Non-cellulosic Polymers**- Arabinoxylans are a combination of connected beta glucans, xyloglucan, mannans, fructan and galactans. These are just slightly soluble in water.
- **Pectic Polysaccharides**- Polygalactouronic acids that can be replaced by arabinogalactan, arabinan, and galactan. These are just slightly soluble in water.

b) Based on Linkage-

- **Water Soluble or Partially Water Soluble**- Beta 1, 4 glycosidic linkage backbones along with beta 1, 3 linkages.
- **Water Insoluble**- Long sequence of beta 1, 4 glycosidic unit.

4.3.2- ROLE OF NON-STARCH POLYSACCHARIDES IN HUMAN HEALTH

The majority of total fibre in diets is made up of insoluble NSP. It satisfies the animals' appetites. A modest amount helps to promote stomach evacuation/defecation and maintain normal gut health. By decreasing the residence time of digestion, a high concentration of dietary fibre lowers digestion and absorption of feed components. Soluble NSPs act as an anti-nutritive substance in the body. It ferments swiftly in the colon and provides energy to anaerobic microbes. It promotes the spread of harmful bacteria like Clostridium perfringens, which causes a number of diseases in animals and poultry.

Consuming fibre increases mucous discharge. It increases nutrition transfer barrier across the epithelial interface by thickening the mucous layer and changing the physiochemical characteristics of mucus. The viscous form of NSP slows digestion and absorption due to nutritional encapsulation.

A high-insoluble NSP-containing meal greatly boosted fermentation in the small intestine. NSP not only interferes with digestion processes, but it also has a considerable negative influence on animal energy and mineral availability. Insoluble NSP-rich meals are very effective at preventing the onset of cannibalism in laying hens. It is due to the bulky structure of fibre and the resulting effect on digestion transit rate.

4.3.3 DISCUSSION ON SOME COMMON NON-STARCH POLYSACCHARIDES

Non-Starch Polysaccharides that are commonly used include:

1- Cellulose-

Condensation, or the elimination of water, joins these glucose molecules and creates (1,4) glycosidic bonds. Each straight chain of cellulose is made up of 100–1000 units. Parallel chains that are joined together by weak hydrogen bonds are known as Cellulose Microfibrils (CM).

CM join together to form microfibrils, which are thicker bundles. (These are frequently referred to as fibres.) In order to create complex structures like plant cell walls, additional substances like hemicelluloses and calcium pectate frequently act as "glue" to bind the cellulose fibres together. Compared to amylose, cellulose has a different overall shape due to the connections. It forms extended straight chains that hydrogen bond with one another to create a very stiff structure.

Cellulose, the most abundant organic substance on the planet, is an important structural polysaccharide. Wood is composed of 50% cellulose, a material found in plant cell walls that provides strength and rigidity. Although it provides critical roughage (dietary fibre) to stimulate stomach contraction and aid in food transit through the digestive system, most animals lack the enzymes required to digest cellulose. Some animals, such as cows, sheep, and horses, can consume cellulose by converting it to glucose utilising bacterial colonies in their digestive systems; ruminants use multiple stomachs to allow the substance to breakdown. Other species, such as rabbits, reprocess previously digested food to give the cellulose more time to break down.

Because of its application in products such as cotton, cellophane, wood, paper, rayon, photographic films (cellulose acetate), linen, and nitrocellulose (guncotton). As a result, cellulose is also useful in the industrial sector.

2- <u>Inulin</u>-

The tubers of dahlias and artichokes, as well as the roots of dandelion, are good places to look for inulin storage. In addition to that, onion and garlic both contain it. Inulin has a molecular weight of about 5,000 and contains 30-35 fructose units per molecule on average.

In plants, it is created by removing a water molecule from the glycosidic OH group on carbon atom 2 of one group and carbon atom 1 of the adjacent β – D – fructose unit.

3- <u>Pectin</u>-

Young plant tissues contain pectins, which are intercellular substances. The pectin content of ripe fruits such as guavas, apples, and pears is especially high. Pectin is a polymer whose carboxyl groups are either completely or partially esterified with methyl alcohol, whereas other carboxyl groups are connected with calcium or magnesium ions. Chemically, they are known as polygalacturonides.

4- <u>Hemicellulose</u>-

Low molecular weight non-cellulosic polysaccharides known as hemicelluloses make up the majority of NSPs. It is only moderately water-soluble.. They typically consist of D – xylose, L – Arabinose, D – glucuronic acid, Dmannose D – galactose ,D – glucose, etc. and are most frequently found as heteropolymers of monosaccharides and less frequently as homopolymers.

5- <u>Gums</u>-

Gums occurring naturally in plants are polysaccharides, which are long chains of sugars that are either water-soluble or water-absorbent. When these polysaccharides are combined with water, gels are produced.

Humans can only partially digest gums and gums normally have little harmful side effects. In the food sector, they are commonly employed as thickeners, emulsifiers, and stabilisers. Due to the fact that they are regarded inert compounds, they are frequently utilised in diet goods and medications.

Animal Polysaccharides-

1- **Glycogen**-

Glycogen is a glucose polymer with many branches that functions as an energy storage compound in mammals, fungi, and bacteria. It is the primary glucose storage type in the human body.

Adipose tissue (body fat) also stores energy in the form of triglycerides, but for a longer period of time than glycogen. Humans produce and store glycogen predominantly in liver and skeletal muscle cells.

Glycogen is found in small quantities in the kidneys, red blood cells, white blood cells, and glial cells of the brain, among other organs and cells. Glycogen is stored in the uterus to provide fuel for the developing baby. Physical exertion, resting metabolic rate, and dietary choices are the primary determinants of glycogen stores in the body.

2- **Chitin**-

Chitin is a polymer found in many different places, from the shells of insects to the webs of spiders. It's found in every kind of plant and animal on Earth. Due to its molecular similarities with cellulose, it is sometimes thought of as a cellulose derivative. The hydroxyl group is present in cellulose, whereas the acetamide can be found in chitin. Chitin is unusual because it is a "natural polymer," or a compound made from elements found in nature.

Humans typically create polymers. Chitin is found in abundance in crabs, beetles, worms, and mushrooms. Chitin is a very stiff material that serves to protect insects from harm.

3- **Hyaluronic Acid-**

It is the most common type of mucopolysaccharide and can be found in the synovial fluid of joints, the vitreous body of the eye, and the umbilical cord of mammals. D-glucuronic acid and N-acetyl-D-glucosamine form alternating chains in this polymer (NAG). The material probably has around 5,000,000 molecules.

4- <u>Heparin-</u>

Heparin, commonly known as unfractionated heparin, is a medicine and glycosaminoglycan that occurs naturally. Heparins are considered anticoagulants since they depend on the activity of antithrombin. In particular, it is also used to treat heart attacks and unstable angina.

4.4 INTRODUCTION TO SUGARS AND SWEETENERS

Since prehistoric times, humans have consumed sweeteners of one kind or another, which are types of carbohydrates. Their inclusion in the healthy-diet is always debated.

A variety of sweeteners, which are also used in foods for purposes other than sweetness, are used by consumers to satisfy their "sweet tooth." Jams and jellies use sugar as a preservative, it gives ice cream and baked goods body and texture, and it helps breads and pickles ferment.

There are both nutritive and nonnutritive sweeteners. Despite missing other nutrients necessary for growth and health maintenance, nutritive sweeteners provide calories or energy at a rate of about four calories per gramme or 17 calories per tablespoon. Examples of healthy sweeteners include sucrose, high fructose corn syrup, fructose, molasses, corn syrup, honey, and sugar alcohols such xylito and sorbitol. Because they don't have calories, nonnutritive sweeteners are sometimes known as artificial sweeteners. Each sweetener has unique uses and limitations. Not between "natural" and "refined," but between concentrated sugars like honey, table sugar, concentrated fruit juices, and corn sweeteners and diluted sweeteners, which are naturally occurring sugars in foods like milk, potatoes, oranges, and corn is the important distinction between sugar sources.

4.4.1- <u>Sugars</u>-

All naturally occurring sugars consist of simple carbs. There are three groups of carbohydrates: monosaccharides (one unit of sugar), disaccharides (two units of sugar), and polysaccharides (many units of sugar).

a) Monosaccharides-

- **Fructose** is the sweetest natural sugar and 1.5 times sweeter than sucrose. It is also referred to as levulose and is present in honey and fruits..
- **Glucose** is present in the majority of plant diets. The primary form into which the body transforms other sugars and carbohydrates is glucose. Since it is the main sugar flowing in the blood, it is referred to as "Blood Sugar." Dextrose is another name for glucose. The wonderful thing about glucose is how quickly it enters the bloodstream and, to a lesser extent, the mouth mucosa.
- **Galactose** is rare in nature as free sugar. It is typically associated with glucose in lactose.

b) Disaccharides-

- **Sucrose** is the most prevalent type of sugar in plants and is a disaccharide made up of two simple sugars. The chemically bound simple sugars glucose and fructose are released during sucrose digestion and taken up by the body for use as fuel. The most widely used industrial and household sugar is sucrose, which is made by condensing sugar from sugarcane or sugar beet juice.

  Although historically "sugar" has meant sucrose, there are now so many other sugars on the market that this could lead to misunderstandings. At several stages, sucrose is purified and granulated to create raw, white, brown, and powdered sugars. During processing, a molasses-colored liquid is created.

- **Lactose** is the sugar found in milk, sometimes referred to as milk sugar. The main purpose of lactose is to give things bulk. It is rarely used as a sweetener because it is the least sweet of all the sugars. Normally, lactase divides lactose into its two monosaccharide components, glucose and galactose. Because they lack or have insufficient amounts of the lactase enzyme, some persons lose their ability to digest lactose and develop lactose intolerance.

Despite the fact that cheese is manufactured from milk, less lactose is present because fermentation turns lactose into lactic acid.

- **Maltose**, also referred to as malt sugar, is created during the brewing of beer and bread. During digestion, maltose is divided into two glucose units so that they can be absorbed.

c) <u>Other Sugars</u>-

- Honey is a plant-based nectar that honey bees make. Fructose and glucose are the same sugars found in both honey and table sugar. Honey contains more calories per equivalent measure than crystalline table sugar because honey is more concentrated. It's a frequent misconception that honey is healthier than sugar. That is misleading. Although it includes trace minerals and B vitamins, the amounts are so little that they have no impact on a diet that is balanced.
- Maple sugar is made by evaporating water from syrup that has been gathered from the mature sugar maples' spring sap flow. The main component of maple sugar is sucrose.
- Cornstarch was processed with acid, heat, and/or enzymes to create corn syrup, a glucose sweetener, in the 1920s. The procedure produced maize syrup as a byproduct. Although corn syrup doesn't have as much sweetness as sucrose, it is frequently used in place of or in addition to sucrose to provide food body and texture.
- High-Fructose Corn Syrup is produced by turning glucose into fructose from corn syrup. This innovative enzymatic technique, discovered in 1970, produces a product that is significantly sweeter, allowing for a reduction in the amount used. The main nutritive sweetener used by the soft drink industry is high-fructose corn syrup, which may also be referred to as corn sweetener or high fructose corn syrup.
- Agave Nectar is a sweetener made from many native Mexican varieties of the agave plant. The primary components of agave nectar are fructose and honey, and its flavour is comparable to honey.
- Sugar alcohols are sweeteners produced from fruits and vegetables or

glucose. Sorbitol, mannitol, maltitol, and xylitol are the most widely used sugar alcohols. The most naturally occurring sorbitol of any fruit that is often consumed in the US is found in prunes. In addition, sorbitol is abundant in apples and pears. Chewing gum, gum coatings, and diabetic candies all include sugar alcohols. Even though items that include sugar alcohol may be labelled "Sugar-Free," "Sugarless," or "No Sugar," they nevertheless contain carbohydrates and calories. Sugar alcohols do not lead to tooth decay. They are absorbed more gradually than carbohydrates, which would explain why they have laxative effects.

4.4.2- **Non-Nutritive Sweeteners**-

Non-nutritive sweeteners must have permission from the Food and Drug Administration in order to be sold in the United States, even though they do not contain any calories when consumed. The FDA has currently approved the use of six non-nutritive sweeteners: saccharin, aspartame, acesulfame-K, sucralose, neotame, and rebaudioside A. Rebaudioside A is an additional choice.

a) Saccharin

In the year 1879, saccharin was discovered, and since then, it has been available for purchase. Saccharin has been used for such a long time without any reported adverse effects that it has been accorded the GRAS designation. There is no evidence that saccharin, when consumed by humans, can lead to the development of cancer. Approximately 300 times sweeter than sucrose, saccharin maintains its sweetness throughout a wide range of temperatures.

Because of a study that was conducted in Canada linking saccharin to bladder cancer in rats, the Food and Drug Administration (FDA) suggested in 1977 that people stop using saccharin. Because of the backlash from the public, Congress decided to put a hold on the FDA's plan to remove saccharin from distribution. The moratorium is still being enforced at this time. Saccharin was taken off of the list of substances that had a reasonable possibility of causing cancer in humans in the year 2000. Warning labels are no longer required to be placed on saccharin.

b) **Aspartame**-

Aspartame is a synthetic sweetener that was discovered in 1965. It has no nutritional value. It has a sweetness that is between 180 and 200 times that of sucrose. In 1981, the FDA approved aspartame for use as a tabletop sweetener and as a component in dry foods such dry beverage mixes and cold cereals. In 1983, the authorization for carbonated beverages was expanded. The FDA established a 50 mg Acceptable Daily Intake (ADI) for aspartame per kilogramme of body weight.

Because it degrades and loses its sweetness when exposed to high temperatures or temperatures that are maintained for an extended period of time, the use of aspartame is restricted at these temperatures. If you are going to use aspartame in your cooking, you should wait until the very end of the cooking process to add it. This will help avoid the product from becoming ruined. If by some chance you heat a food that contains aspartame, the item will still be safe to consume, but it won't have the desired level of sweetness.

Although the safety of aspartame has been questioned by some people, it is one of the ingredients that has been put through the most rigorous testing in the food chain. The ADI represents a daily intake recommendation that should be adhered to throughout one's entire life and includes a built - in safety factor. In studies conducted with humans, consumption of significantly higher doses of aspartame than the ADI did not result in any adverse effects.

c) **Acesulfame-K**-

In July of 1988, the FDA gave its approval for the use of acesulfame-K as a sweetener that is free-flowing on tabletop surfaces, in addition to being used in chewing gum, puddings, and dry-base beverage mixes. The "K" stands for potassium in this equation. Acesulfame-K has a sweetness that is approximately 200 times that of sucrose.

Acesulfame-K can withstand high temperatures and is hence suitable for use in baking. The sweetness of foods can be maintained throughout time with the help of acesulfame-K, which extends the amount of time that items can remain sweet. Foods with Acesulfame-K mixes have up to 40% less total sweetness overall than foods without these blends. This sweetener is frequently used with other low-calorie sweeteners to produce a flavour that is more like to sugar than any of the low-calorie sweeteners provide when used alone.

The FDA has determined that the recommended daily intake (ADI) for acesulfame-K is 15 mg per kg of body weight. Acesulfame-K contains a small amount of potassium, but not nearly as much as potassium found naturally in meals. The structure of sulphur is different from that of sulfites or sulfa medicines, both of which have been known to cause allergic reactions, despite the fact that it contains sulphur.

d) **Sucralose-**

Sucralose was approved by the FDA in April 1998. It is the only non - nutritive sweetener made from sucrose and is around 600 times sweeter than sugar. Sucralose is legal to use as a tabletop sweetener, in processed fruit juices and other fruit products, salad dressings, baked goods, and dairy products. Products made with sucralose maintain their sweetness even after extended periods of storage, baking, and cooking.

e) **Neotame**-

Neotame's use was authorised by the FDA in 2002. Three molecules of 3-dimethylbutyaldehyde with the two amino acids aspartic acid and phenylalanine make up the compound neotame. Between 30 and 60 times sweeter than aspartame, it is between 7,000 and 13,000 times sweeter than sucrose. A warning label is not necessary because neotame is not significantly converted to phenylalanine. It was approved for use as a general-purpose sweetener in addition to meat and poultry. Additionally, it can withstand heat and be utilised in baked foods.

f) **Rebaudioside A**-

In 2008, the FDA approved Rebaudioside A for use as a sweetener. Prior to 2008, it could only be offered for sale as a dietary supplement. A refined stevia plant product is Rebaudioside A.

g) **Cyclamates**-

Cyclamate is a 30 times sweeter than sugar nonnutritive sweetener that blends well with other calorie-free sweeteners. When mixed with other low-calorie sweeteners, cyclamate has a synergistic effect that lowers the overall amount of sweeteners needed. Since its discovery in 1937, it has been legal to use in foods and beverages in more than 50 nations, including Canada, Australia, and Mexico. Although it was made illegal in the US in 1970, the FDA is currently considering a petition to re-approve cyclamate.

4.4.3- Working Mechanism of Non-Nutritive Sweeteners-

A sweetening agent needs to be water soluble and simple to bind to the receptor molecule on the surface of the tongue in order to work effectively. The sweetener interacts with the receptor to produce the sweetness of an artificial sweetener. The receptor is actually connected to a G- protein, and when the sweetener binds to the receptor, the G- protein starts to dissociate, triggering an event sequence in which the signals are transmitted to and interpreted by the brain.

Our tongue's surface is frequently covered with several taste buds, each of which has a number of taste receptors that can discern different flavours. Our taste receptors come into contact with food molecules as we eat.

Our brain receives a signal when a chemical and a receptor are in perfect alignment, enabling us to identify the taste. For instance, the sugar molecule exactly fits into our taste receptor for sweetness, enabling the brain to differentiate the sweetness of food.

Artificial sweetener molecules resemble sugar molecules sufficiently to fit on the sweetness receptor. However, they differ significantly from sugar in terms of how many calories they contain. They provide a sweet taste without adding extra calories, which is why they are known as Non-Nutritive Sweeteners.

4.5 INTRODUCTION TO FERMENTATION

Sugar is fermented into acids, fumes, or alcohol as part of a metabolic process. Lactic acid fermentation occurs in yeast and bacteria, as well as in oxygen-starved muscle cells. The term "fermentation" can also be used to describe the widespread multiplication of microorganisms on a growth medium for the purpose of extracting a desired chemical, such as an enzyme, a vaccine, an antibiotic, a food product or additive, and so on. French microbiologist Louis Pasteur is famous for his research into the microbial origins of fermentation. The study of fermentation, or zymology.

Without oxygen, the electron transport chain can't generate energy, thus fermentation steps in as the cell's primary source of ATP (energy). Fermentation has been used by humans to produce food and drink since the Neolithic era. Sour foods like pickled cucumbers, kimchi, and yoghurt, and alcoholic beverages like wine and beer are all preserved by the fermentation process, which produces lactic acid. Animals, including humans, can undergo fermentation in their stomachs.

4.5.1- Types of Fermentation-

1. **Ethanol Fermentation or Alcoholic Fermentation**- The process involves creating ethanol and carbon dioxide.

2. **Lactic Acid Fermentation**- Further classified as-

- **Homolactic Fermentation** exclusive to the synthesis of lactic acid
- **Heterolactic Fermentation** is the process of producing lactic acid as well as other acids and alcohols.

Sugar is the most common fermentation substrate, while the most common fermentation products are ethanol, lactic acid, carbon dioxide, and hydrogen gas (H2). Fermentation, on the other hand, can produce more new compounds such as butyric acid and acetone. Yeast is responsible for the fermentation of ethanol in beers, wines, and other alcoholic beverages, as well as the production of massive volumes of carbon dioxide. Fermentation occurs in mammalian muscle during moments of intense exercise when oxygen supply is limited, resulting in lactic acid generation.

a) Ethanol Fermentation or Alcoholic Fermentation-

The alcoholic fermentation of glucose ($C_6H_{12}O_6$) is illustrated by the following chemical equation. Two molecules of ethanol and two molecules of carbon dioxide are created from one glucose molecule.

$$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$$

Ethanol has the chemical compostition **C_2H_5OH**. Prior to fermentation, one glucose molecule is split into two pyruvate molecules. This process is known as glycolysis.

Lactic Acid Fermentation-

Homolactic Fermentation- The simplest fermentation process is one that solely produces lactic acid. When pyruvate from glycolysis is subjected to a straightforward redox mechanism, lactic acid is created. Being one of the few respiration processes that does not result in the production of gas byproducts, it is exceptional. Two molecules of lactic acid are created from one glucose molecule (or any sugar with six carbons).

$$C_6H_{12}O_6 \rightarrow 2CH_3CHOHCOOH$$

It happens when an animal's muscles need oxygen-rich blood more quickly than the blood can provide it. Additionally, it is present in several fungi and bacteria, including Lactobacilli. By converting the lactose in yoghurt to lactic acid, this type of bacterium gives it its sour flavour. Both homolactic and heterolactic fermentation are possible with these lactic acid bacteria.

Heterolactic Fermentation- In cases where lactate is further metabolised, various metabolic products such as ethanol, carbon dioxide, acetate, and so on are formed as:

$$C_6H12O6 \rightarrow CH3CHOHCOOH+C2H5OH+CO2$$

When lactose is fermented (as it is in yoghurt and cheese), it first becomes glucose and galactose, both of which have six carbons and the same atomic formula as:

$$C12H22O11 + H2O \rightarrow 2\ C6H12O6$$

Between lactic acid fermentation and other types, including alcoholic fermentation, is heterolactic fermentation.

Process of Fermentation-

Anaerobic conditions are present during fermentation. The production of pyruvic acid by glycolysis, where net 2 ATP molecules are created, is the first stage of fermentation, which is equivalent to the first stage of cellular respiration. Pyruvate is transformed into lactic acid, ethanol, or other compounds in the following stage. NAD+ is created here and used again during the glycolysis process.

Significance of Fermentation-

Fermentation is compatible with all surroundings. It is one of the most ancient metabolic pathways shared by eukaryotes and prokaryotes. Fermentation is utilised extensively in numerous sectors.

Using specific microbes and environmental circumstances, the following fermentation products are produced:

- Beer
- Biofuels
- Pickles
- Bread
- Wine

- Yoghurt
- Certain antibiotics and vitamins
- Sour foods containing lactic acid

Fermentation can improve the nutritive value, digestibility, and flavour of food. There are numerous advantages to ingesting fermented foods.

- It enhances digestion and aids in the maintenance of gut microorganisms.
- Reduces lactose intolerance
- It possesses anti-cancer properties.
- Improves immune system

Fermentation is used in many different businesses than the food industry. Methane is produced during fermentation in sewage treatment facilities and freshwater sediments.

4.6 NON-ENZYMATIC BROWNING

Foods acquire their brown colour through a chemical process called non-enzymatic browning. The caramelization of sugars as well as quinines' interactions with amines and amino acids cause non-enzymatic browning in addition to the caramelization of sugars and quinine's interactions with amines and amino acids.

4.6.1-Caramelization-

The heating of carbohydrates is a process known as caramelization, commonly referred to as sugar pyrolysis. The finished product is made up of a complex mixture of polymeric elements. Sugar molecules lost their moisture due to the intense heat, which also resulted in the development of double bonds and an anhydro ring. The following sorts of reactions are all a part of caramelization:

- Anomeric and Ring Structure Equivalence
- Sucrose to fructose and glucose conversion
- Synthesis processes

- Bonding within molecules
- Ketoses via aldose isomerization
- The methods of dehydration
- Processes of fragmentation
- Synthesis of unsaturated polymers

The process is temperature-dependent. To enhance and create different classes of caramels, a number of acids (phosphoric, food grade sulfuric, acetic, and citric acid), bases (potassium, ammonium, sodium, and calcium hydroxide), and salts (sodium, ammonium, and potassium carbonates, bicarbonates, sulphates, and bisulfites) are used as catalysts. The most common type of sugar is sucrose, although other options include D-fructose, D-glucose (Dextrose), glucose syrup, and molasses.

4.6.2- The Maillard Reaction-

An amino acid and reducing sugar undergo a chemical process known as the Maillard reaction, which frequently calls for heat. It is a non-enzymatic kind of caramelization, which is a browning process. When the nucleophilic amino group of the amino acid interacts with the reactive carbonyl group of the sugar, fascinating but poorly understood smell and flavour molecules are created. This process accelerates in an alkaline environment because the amino groups are not neutralised. Since the type of amino acid used determines the flavour that is created, this reaction is the basis of the flavouring industry. During the process, hundreds of unique flavour components are produced. As these molecules break down, new flavour compounds are created, and so on. Each type of food generates a unique set of flavouring compounds during the Maillard reaction. These compounds have been used by flavour experts to create false flavours over the years.

4.6.3- Factors affecting the Maillard Browning-

- The rate of browning increases between 0.3 and 0.7 water activity.
- As pH rises, Maillard browning increases (slightly alakaline medium)

- As the temperature rises, browning increases.
- To prevent browning in fish, ribose oxidase from Lactobaccilus pentoaceticum is utilised.
- Browning is avoided by sulfites and sulphur dioxide, which interact with aldehyde and keto groups.

4.7 LET US SUM UP

The primary focus of this section was on the many facets of carbohydrates, such as polysaccharides, which encompasses starch and non-starch molecules, sugars, and sweeteners. The body relies almost entirely on carbohydrates as its primary source of the energy that it needs to function. Therefore, the information regarding the primary carbohydrate molecules that are present in food may be obtained more easily thanks to this unit. The molecular forms of starch and non-starch carbohydrates are the main topics of this lesson. The course went on to address the many types of sugars and syrups, as well as the various kinds of sweeteners, which are also referred to as non-caloric sweeteners or artificial sweeteners. In addition, the unit provides information about the chemistry that is involved in the functioning mechanism of artificial sweeteners. In addition, this lesson covered a variety of topics pertaining to the process of fermentation, as well as non-enzymatic browning. Therefore, the knowledge required for this subject includes information about the many kinds of carbohydrates and the chemistry that is associated to them.

4.8 KEYWORDS

Monosaccharide ---- A monosaccharide is a specific kind of carbohydrate that cannot be further digested to produce a simpler polyhydroxyaldehyde or ketone. It is impossible to divide this kind of carbohydrate into smaller components.

Oligosaccharides ---- Oligosaccharides are a class of carbohydrates that, when hydrolyzed, release anywhere from two to ten monosaccharide units.

Polysaccharides	----	Polysaccharides are a class of carbohydrates that, when hydrolyzed, release a significant number of monosaccharide units.
Starch	----	A vast number of monosaccharide units are packed into polysaccharides, and these units are linked to one another by glycosidic connections. Amylose and amylopectin are the two components that make up this -glucose polymer, which can also be described as a glycopolymer.
Non-Starch Polysaccharides	----	Carbohydrate fractions that do not include starch or free sugars are referred to as non-starch polysaccharides, or NSPs.
Glycogen	----	It is also known as animal starch due to its structure, which is relatively similar to that of amylopectin but is slightly more extensively branched.
Fermentation	----	The conversion of sugar into acids, gases, or alcohol is accomplished by a metabolic process known as fermentation.
Non-Enzymatic Browning	----	Browning that is not caused by enzymes is a chemical process that gives foods their characteristic brown hue.

4.9- CHECK YOUR PROGRESS EXERCISE

1- Write down about Starch. What is the major composition of Starch?

………………………………………………………………………………
………………………………………………………………………………
………………………………

2- Write down a short note on “Non-Starch Polysaccharides”.

………………………………………………………………………………
………………………………………………………………………………
………………………………

3- Briefly explain about the "Significance of Fermentation"

………………………………………………………………………………

………………………………………………………………………………

………………………………

4- Write down a short note on "Artificial Sweeteners"

………………………………………………………………………………

………………………………………………………………………………

………………………………

Fill in the Blanks-

1. Starch contains two types of glucose chains ……………..and ……………………..
2. Artificial Sweeteners provides about………………..calories.
3. ……………………………describes the process through which anything transforms into a substance similar to jelly.
4. …………………………..is a chemical process that gives foods a brownish appearance.

State weather the statement is True or False-

1. Oligosaccharides are a class of carbohydrates that, when hydrolyzed, release a significant number of monosaccharide units.
2. The conversion of sugar into acids, gases, or alcohol is accomplished by a metabolic process known as fermentation
3. Artificial Sweeteners also known as Non-Nutritive Sweeteners.
4. Carbohydrate fractions that do not include starch or free sugars are referred to as Fibre.

UNIT-5 CEREALS AND CEREAL PRODUCTS

Structure-

1.0 Objective

1.1 Introduction- Cereals

1.2 Structure of Cereals Grain

- 1.2.1 Bran or Pericarp
- 1.2.2 Aleurone Cell Layer
- 1.2.3 Endosperm
- 1.2.4 Embryo

1.3 Composition and Nutritive Value of Cereals

1.4 Specific Cereal and Millets

- 1.4.1 Rice
- 1.4.2 Wheat
- 1.4.3 Millets

1.5 Processing of Cereals

- 1.5.1 Types of Cereal Processing
- 1.5.2 Methods of Cereal Processing

1.6 Cookery of Cereals

- 1.6.1 Gelatinisation
- 1.6.2 Gluten Formation
- 1.6.3 Dextrinisation

1.7 Benefits of Cereals

- 1.7.1 Benefits of Cereals in Cookery
- 1.7.2 Health Benefits of Cereals

1.0 OBJECTIVE

After reading this unit, Students will able to-

- Understand the makeup and structure of cereals.
- Knowing how to preserve different cereal products while cooking and their nutritional worth.
- Select appropriate processes and preservation methods for Cereal Products and manufacture Processed Cereals and cereal Products with enhanced shelf-life.

1.1 INTRODUCTION OF CEREALS

The seeds of the grass family are cereal grains. The Roman grain goddess "Ceres" is where the term "cereal" comes from. The most significant cereal crops are bajra, jowar, ragi, jowar, wheat, and corn. Along with this, cereal also includes flours, meals, breads, and edible pastes or pasta. The majority of the world's calories and roughly half of its protein come from cereal grains. These grains are consumed as significant nutritional components either directly or indirectly (flour, starch, oil, bran, sugar syrups and numerous additional ingredients used to manufacture other foods).

Cereal foods are widely consumed due to their simplicity of production and storage, as well as their comparatively low cost and nutritional value. They are staples in the diets of the majority of demographic groupings.

1.2 STRUCTURE OF CEREALS GRAINS

Every grain has the same basic structure. The seed coat is made up of multiple internal layers as well as an epidermis (outer layer). Just below the seed coat is the aleurone layer, which contains oils and various nutrients such as minerals, proteins, and vitamins. The outer layer known as the bran, which makes up around

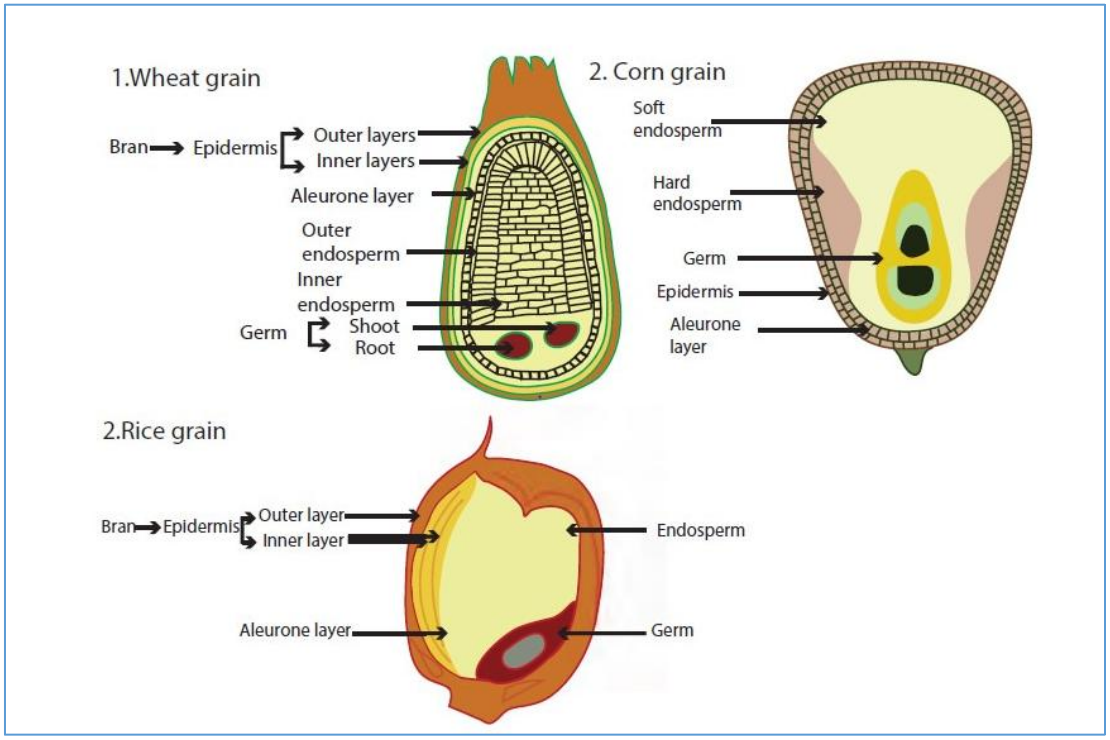
13% of the grain, is made up of the seed coat and aleurone. The endosperm, the primary component of the grain, is enclosed by the aleurone layer (usually about 85 percent). Storage cells that contain starch granules enclosed in a protein matrix make up the endosperm. The part of the grain that sprouts is called the germ. Around 2% of the seed is found in wheat, but 65% of the B group vitamins and 33% of the oil are.

The major part of the Structure of the Cereals-

1.2.1- <u>Bran or Pericarp</u>-

The cereal's epidermis, or outer layer, is made up of long, rectangular cells with thin walls. The variable-thickness hypoderm is located next to the epidermis. As the seed ripens, the pericarp's innermost layer breaks, and in the mature grain, this is symbolised by a layer of tube cells that resembles branching hyphae.

The **Seed Coat** or **Testa** is either a single layer or two layers of thin material. The inner layer of wheat's testa is frequently densely coloured, giving the grain its distinctive hue. Hyaline (also known as nuclear tissue), which lacks obvious cellular structure and is colourless, is the next tissue to be investigated.



1.2.2- **Aleurone Cell Layer**-

The endosperm may be surrounded by one or more layers of cells known as the aleurone. The aleurone makes up 7% of the total weight of a wheat grain and consists of a single layer of cubical cells with strong walls. Protein, oil, and mineral stuff all make up approximately 20 percent of the cell's total composition. Nicotinic acid is also found in high concentrations within the cells. In addition, the aleurone cells have a few protein molecules and very little grains of phytic acid.

1.2.3- **Endosperm**-

The endosperm itself is made up of cells that range in size, shape, and composition, all of which are distinct from one another. The bulk of an endosperm cell is made up of starch and protein, with the starch appearing as solitary or clustered spherical granules wrapped in a protein matrix. There is a wide range in the size and shape of the starch granules found in the endosperm cells of grains.

1.2.4- **Embryo**-

There are many parts that work together to form the germ or embryo. The scutellum separates the embryo from the endosperm and carries the endosperm's nutrient stores to the developing seedling. There is a wealth of protein and lipids in the germ and scutellum. The scutellum is where you'll find the vast majority of the grain's B vitamins.

1.3 COMPOSITION AND NUTRITIVE VALUE OF CEREALS

Cereals provide 70–80 percent of the energy we need, making them our primary energy source. Carbohydrates make up 80% of the dry matter of cereals. There are two types of carbohydrates present: soluble carbohydrates and cellulose, an insoluble fibre. Protein in cereals, which ranges from 6 to 12 percent, is lysine deficient. Protein in cereals is of higher grade than other types. In wheat, rice, and maize, fat content ranges from 1-2 percent to 3 percent. Cereals are not very high in calcium and iron, with the exception of ragi.. Cereals made from whole grains are a significant dietary source of B vitamins.

The details of composition of different Cereals are as follows-

- **Energy:** Cereals contribute between 70 and 80 percent of the required energy supply. One hundred grammes yield almost 340 kcal of calories.
- **Carbohydrates**: The dry matter of grains is made up of 80% carbohydrates. The two carbohydrates that are present are soluble carbohydrate and coarse fibre. The fibres cellulose, hemicelluloses, and pentosans are abundant in all cereals. There are also trace amounts of dextrin and carbohydrates present. Simple sugars such as glucose are present, as are disaccharides such as sucrose and maltose. Whole wheat, ragi, and bajra provide the most fibre of all cereals.
- **Protein**: The amount of protein in various grains varies. Rice provides significantly less protein than other grains. The protein composition of several types of the same grain differs as well. There are proteins in every tissue of the wheat grain. Concentrations are higher in the embryo, scutellum, and aleurone layer than they are in the endosperm, pericarp, and testis. In the endosperm, protein concentration rises from the centre to the edges. Protein types found in cereals include albumins, globulins, prolamines (gliadins), and glutelins. Different grains contain these proteins in varying amounts. Gluten proteins are known as gliadins and glutelins. Gluten's characteristic flexibility and fluidity are utilised in the baking of bread and other items.
- Cereals are typically lacking in lysine and contain 6 to 12 percent protein. Due to their high consumption, they supply more than 50 percent of the daily protein need. Rice protein has the highest quality among cereal proteins. The protein quality of cereals is enhanced when ingested with pulses due to mutual supplementing. Cereals lack lysine but are high in methionine. Pulses are methionine-deficient and lysine-rich. Thus, the protein quality of both proteins has improved.

- **Lipids**: Wheat and rice contain 1-2 percent lipids, while maize contains 3 percent lipids. Germ and bran contain more lipids than other sections of the grain. Wheat germ contains lipids at 6-12%, bran at 3-5%, and endosperm at 0.8-1.5%. The lipid content of maize bran is 1%, while that of the germ is 35%. Triglycerides comprising palmitic, oleic, and linoleic acids make up the bulk of the lipids. Cereals also have phospholipids and lecithin, which are fat-like substances. It is estimated that the fat included in cereals can provide more than half of the essential fatty acids we need, which makes sense given the quantity of grain eaten. Almost all of an adult's fatty acid needs can be satisfied by a diet of cereals and pulses.

Minerals: About 95% of all minerals are found in the phosphates and sulphates of potassium, magnesium, and calcium. The presence of phosphorous in grains, in the form of phytin, accounts for a sizeable portion of its total content. Phosphorous and calcium found in phytin cannot be absorbed by the body because of its structure. Cereals typically include phytates, which inhibit the body's ability to absorb iron. Cereals that have not been refined or polished have a higher phytate content than cereals that have been processed. Enzymatic degradation of phytate occurs after grain germination, leading to lower phytate levels and more iron availability. Cereals also contain trace amounts of other mineral elements, such as copper, zinc, and manganese, albeit at extremely low concentrations.

Rice, in particular, is a very poor supplier of calcium and iron, and cereals in general are not very good sources of any of these minerals. The level of polishing directly affects the content of the product. Calcium and iron are both found in high concentrations in ragi. Millets (such as ragi, bajra, and jowar) include an abundance of nutrients and fibre. The use of iron rollers in the milling process causes an increase in the amount of iron that is contained in wheat.

- **Vitamins**: Cereals derived from whole grains are crucial to a healthy diet due to the B vitamins they contain. Because most B vitamins are contained in the bran, refining or polishing the grains reduces the quantity of B vitamins they contain. Parboiling, in which paddy is first steeped in water before being steamed, allows the rice's outer layer vitamins to permeate the grain. Milled, polished, and parboiled rice retains a high concentration of B vitamins. The B vitamin level of maida is significantly lower than that of whole wheat flour. Except for maize, which contains very small levels of carotenes, cereals do not contain vitamin A or vitamin C. Cereal grain oils are a great place to get your vitamin E intake for the day.

- Enzymes: Some grains have a large number of enzymes, the most important of which are the amylases, proteases, lipases, and oxidoreductases. The amylase activity boosts once the seed has germinated. The germ contains a disproportionately high number of proteases. The lipases found in cereals are to blame for the formation of fatty acids that take place during the storage of cereals and the products made from cereals.

Food	Energy (Kcal.)	Protein (g)	Fat (g)	Carbohydrate (g)	Calcium (mg)	Phosphorous (mg)	Iron (mg)	Carotene (mcg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)
Bajra	361	11.6	5.0	67.5	42	296	8.0	132	0.33	0.25	2.3
Jowar	349	10.4	1.9	72.6	25	222	4.1	47	0.37	0.13	3.1
Maize,dry	342	11.1	3.6	66.2	10	348	2.3	90	0.42	0.10	1.8
Maize, tender	125	4.7	0.9	24.6	9	121	1.1	32	0.11	0.17	0.6
Oat meal	374	13.6	7.6	62.8	50	380	3.8	0	0.98	0.16	1.1
Ragi	328	7.3	1.3	72.0	344	283	3.9	42	0.42	0.19	1.1
Rice, parboiled, handpounded	349	8.5	0.6	77.4	10	280	2.8	9	0.27	0.12	4.0
Rice, parboiled, milled	346	6.4	0.4	79.0	9	143	1.0	-	0.21	0.05	3.8
Rice. Raw. Handpounded	346	7.5	1.0	76.7	10	190	3.2	2	0.21	0.16	3.9
Rice, raw, milled	345	6.8	0.5	78.2	10	160	0.7	0	0.06	0.06	1.9
Rice bran	393	13.5	16.2	48.4	67	1410	35	-	2.7	0.48	29.8
Rice flakes	346	6.6	1.2	77.3	20	2380	20	0	0.21	0.05	4.0

Rice puffed	325	7.5	0.1	73.6	23	150	6.6	0	0.21	0.01	4.1
Wheat Flour (Whole)	341	12.1	1.7	69.4	48	355	4.9	29	0.49	0.17	4.3
Wheat Flour (Refined)	348	11.0	0.9	73.9	23	121	207	25	0.12	0.07	2.4
Wheat bread (White)	245	7.8	0.7	51.9	11	-	1.1	-	0.07	-	0.7

Source: Gopalan C., Rama Sastri B.V. and Balasubramanian S.C., 1991. Nutritive value of Indian Foods, National Institute of Nutrition, ICMR, Hyderabad

1.4 SPECIFIC CEREALS AND MILLETS

List of Some Frequently Used Grains and Millets -

1.4.1. Rice

Rice has between 72 and 75 percent starch, making it the primary source of carbohydrates in this grain. The percentage of protein that rice contains is seven percent.

Types of Rice

There are several varieties of rice, including-

Basmati Rice: In India, biriyanis and pulaos are generally made with basmati rice, a long-grain variety with a delicate texture that has been grown, found, and used for centuries.

Sticky Rice: This type of rice, commonly referred to as sticky rice, is mostly farmed in Asia.

Parboiled Rice: It is a specific sort of rice that, unlike brown rice, is prepared by steaming and drying with the outer shell still attached. The outer layer is then eliminated to produce a rice variety that is better in nutrients and less clumpy.

Polished Rice: The majority of the protein and vitamin content in rice that has been milled into polished rice has been removed during the milling procedure. It is believed that polished rice, like regular white rice, has a lower nutrient density than unpolished rice.

Long-Grain Rice: These rice grains are about four to five times longer than they are wide, and they tend not to clump together when cooked.

Medium-Grain Rice: These grains of rice tend to be delicate and chewy, and they are about twice as long as they are wide.

Short-Grain Rice: This type of rice is slightly longer than it is wide and tends to cluster together, therefore it is sometimes misidentified as medium-grain rice.

Brown Rice: Brown rice is rice that has not had the inner husk removed. This means that because the rice hasn't been milled, it has a much higher concentration of fibre and minerals. It is whole grain that has not been treated and still has all of its original bran, germ, and endosperm. When compared to brown rice, which has higher amounts of all of these nutrients, rice that has been manually pounded, undermilled, or polished has lower levels of protein, dietary fibre, vitamins, and minerals.

Black Rice: Its dark colour is due to the high concentration of anthocyanins in it. This nutrient-rich and rather uncommon rice variety is becoming more and more well-liked in Indian cuisine.

Red Rice: Similar to black rice, red rice has a distinctive anthocyanin content that gives it its colour. This is what gives the husk its red colour, which can be removed entirely or partially before preparing this kind of rice.

Different Rice Products-

Parched Rice Products: This comprises flaked, puffed, and parched rice. They are simple to digest, making them suitable for both young and old. It gives the diet more diversity. A good source of iron is rice flakes.

Rice Bran: The pericarp and aleurone layer of the bran contain a number of sublayers. Antioxidants are abundant in bran. Rice bran is used to make oil.

Broken Rice: It is mostly used to prepare upma.

Rice Flour: Rice starch granules are encased in a protein matrix and are quite tiny. Puddings, ice creams, and custard powder all include it.

1.4.2. Wheat

Wheat grains have rounded ends and an oval shape. Wheat proteins are abundant in glutamic acid but low in tryptophan. Whole wheat contains thiamin, riboflavin, niacin, folic acid, calcium, phosphorus, zinc, copper, and iron. Wheat is a food that is high in fibre. Most wheat is consumed as flour, which is made by milling the grain, though some is also made into breakfast foods like wheat flakes and puffed wheat.

Flour, which is created by milling wheat, is used to make a variety of goods worldwide, including bread. Gluten, a protein found in wheat, is necessary for the fundamental composition of the dough system used to create bread, rolls, and other baked goods. Bread, cookies, cakes, pies, pastries, cereals, crackers, pasta, flour tortillas, and noodles are just a few of the everyday foods made using wheat flour.

Products of Wheat-

Maida: It is additionally known as refined flour. The bran and germ are separated to create maida or white flour. Maida is easier to digest, bakes more uniformly into a larger loaf, and has a blander flavour. The nutritional quality decreases as the level of refining increases.

Macaroni Products: These goods are also known as pasta. Noodles, vermicelli, macaroni, and spaghetti are among these goods.

Wheat Bran: Wheat Bran offers health advantages and is a concentrated source of insoluble fibre.

Wheat Germ: It has a lot of fibre, healthy fats, and vegetable protein. It also includes potassium, phosphorus, magnesium, thiamine, and vitamin E.

Wheat Rava: Making upma, bisi bela bath, pongal, etc. requires the usage of broken wheat, also known as wheat rava.

Whole Wheat Flour: It includes the finely crushed bran, germ, and endosperm from the entire kernel. Chapattis, puris, whole wheat bread, and other things are made using it.

<u>Wheat Flakes</u>: They are consumed as cereals for breakfast. They are loaded with nutritional fibre, and the majority of kinds have been enriched with a wide range of important vitamins and minerals.

<u>Semolina</u>: Its chemical makeup is comparable to that of white flour and it is endosperm that has been roughly milled.

3. <u>Oats</u>

Being a whole grain, oatmeal. Because the bran and germ are left in all oat products, including oat meal, oat flakes, and oat bran, they are all healthful. Beta glucans, a form of soluble fibre that decreases blood cholesterol, are abundant in oats.

4. <u>Barley</u>

Baking, processed goods, vinegar production, and syrup production all need barley malt.

1.4.3- <u>Millets</u>

India's main millet crops are:

<u>Finger Millet / Nachani / Kezhvaragu</u>: Other names for it include red millet, ragi, and finger millet. It's well known in southern India. There is a lot of protein in this millet. Prolamins and glutelins, the two primary proteins found in ragi, appear to have sufficient amounts of all nine necessary amino acids. Ragi is a strong source of iron and abundant in minerals, particularly calcium. A weaning diet heavy in calories but also nutrient-dense can be made by combining malted ragi flour and germinated green gramme flour. Milk beverages go well with ragi flour.

<u>Pearl Millet / Bajra /Kambu</u>: The largest producer of pearl millet in the world is India. This millet contains a lot of phosphorus, which is important for the structure of cells in the body. The protein content is equal to that of wheat.

Sorghum /Jowar /Cholam: The main reason sorghum is farmed is for its high feed value. Protein, unsaturated fats, fibre, and minerals like phosphorus, calcium, potassium, and iron are all rich in sorghum.

Kodo millet/Kodra/Varagu: The high concentration of polyphenols in kodo millet serves as an antioxidant. It is low in fat and high in fibre.

Barnyard Millet / Jhangora / Kuthiravali: Barnyard millets are a wonderful source of calcium, phosphorus, and fibre.

Foxtail Millet /Kangni / Thinai: Iron-rich and pest-free foxtail millets are available. Foxtail has anti-pest properties that make it useful for preserving sensitive pulses like green gramme.

Little Millet / Kutki / Saamai: Compared to other millet varieties like foxtail millet, the seeds are smaller. Little millet contains a lot of iron and fibre, just like Kodo.

Health Benefits of Millets-

The various health benefits of millets are:

Assist Digestion: Millets' high fibre content aids in improving digestive health and curing conditions including excessive gas, constipation, cramps, and bloating.

Detoxification: Antioxidants included in millet aid to fight off free radicals that can cause cancer and remove toxins from the liver and kidneys.

Prevent Diabetes: Due to its adequate magnesium content, it helps to lower the risk of Type 2 diabetes.

Healthy Heart: Magnesium, which is included in millets, helps to control blood pressure and lowers the risk of stroke, heart attack, and atherosclerosis.

Respiratory Health: According to research, millet helps to avoid asthma while also enhancing respiratory health.

Balance Cholesterol Level: The high fibre content of millet contributes to lowering cholesterol.

Prevent Cancer: According to research, fibre is the most straightforward strategy to stop the spread of breast cancer in women. Millets can reduce the risk of breast cancer since they are high in fibre.

1.5 PROCESSING OF CEREALS

1.5.1 **Types of Cereal Processing**-

1. **Primary Processing of Cereals**

Separating the outer layers of the grain from the centre is the primary objective of processing entire cereal grains. The germ and bran are eliminated during the milling process to produce white flour. Throughout the milling process, the grains are crushed and pulverised. Each type of grain has a milling process that is somewhat unique.

Following grain milling, the end products can be categorised as follows:

- Products labelled as "whole grain" or "whole meal" use the complete grain, including the endosperm, bran, and germ. As the oil component in the germ oxidises with time, whole grain products may develop off flavours.
- Products that are only made from endosperm are considered refined (starch). The germ and bran are thrown out. Due to their high carbohydrate content, refined foods have a longer shelf life but are nutritionally insufficient.
- Vitamins and minerals are typically added to enriched products to offer them nutritional qualities similar to those of whole meal products without the fibre content.
- Grain that has been ground or milled is transformed into flour, a fine powder.
- More coarsely grained than flour is meal.

- Before being dried, Instant or Quick-Cook foods have been fully or partially cooked. When reconstituting them, relatively little preparation time is required. Some examples include instant Asian-style noodles, quick-cook rice, and instant oatmeal.

2. **Secondary Processing of Cereals**-

Different items can be made from cereals after they have been processed again. The primary outputs are:

- Flakes for breakfast cereals are often made by rolling and baking the cereal. Example: wheat flakes.
- Baked goods, including bread More steps, including sifting, mixing, kneading, proofing, and baking, are needed for baked goods including savoury crispbreads, sweet biscuits, cakes, and pastries. Yeast and baking powder are two examples of leavening agents used in baking.
- Commercially produced Extruded Snack Foods are made by extruding a dough or batter into fun forms before baking. Macaroni pasta, for instance, is made by shaping flour dough into various forms by hand or with a pasta machine.
- Flour doughs are formed into noodles and dumplings, which are then cooked in broth or water.

1.5.2 **Major Processing Methods for Cereal Processing**-

1. Milling

- The preparation of cereals is a difficult task. The milling process entails grinding the grain into a finer consistency before it can be used in cooking. The following procedures make up the milling process:
- By passing the rice between two rubber stone discs spinning at various speeds, the hull may be easily removed without damaging the grain.

- After that, it goes through a pearlor machine, where the bran and germ are rubbed away, leaving behind unpolished milled rice.
- Due to the susceptibility of unpolished rice to rancidity, the aleurone layer is removed during the polishing process in a brush machine.
- The polished rice is typically given an even higher sheen by being coated with sugar and talc in a contraption called a trumbol.
- During milling, nutrients such as protein and fat are degraded at a rate of 15% and 80%, respectively; thiamine is degraded at a rate of 85%; riboflavin is degraded at a rate of 70%; and pyridoxine is degraded at a rate of 50%. The level of milling determines the nutritional loss.

2. Parboiling

Parboiled rice has been partially boiled while still in its husk.

This improves the rice's nutritional profile and alters its texture while making it more manageable for hand processing.

1. **<u>Conventional Process</u>**: The steps in this are as follows:

- Paddy is immersed in large cement tanks in the cold for two to three days.
- Sun drying after 5–10 minutes of steaming the soggy paddy

2. **<u>Hot Soaking Process</u>**: This consists of the following steps:

- 3–4 hours of paddy soaking in 65–70° C. water
- Draining the water and heating the soaked rice for 5–10 minutes in the same vessel, and
- Paddy drying in the sun or with industrial dryers

<u>Advantages of Parboiling-</u>

1. It is simple to dehusk parboiled rice.
2. The resistance of milled parboiled rice to fungi and insects is higher.
3. Nutrient losses resulting from the removal of husk and bran during milling are reduced.
4. Parboiled rice loses fewer water-soluble nutrients during washing than uncooked rice does.
5. Digestibility is enhanced by parboiling.

3. **<u>Malting of Cereals</u>**

Malting is a controlled germination procedure that awakens dormant grain enzymes, causing cereal proteins and other macromolecules to be converted. Malt is frequently produced using barley as a raw material. Other grains used to make malt include wheat, jowar, and ragi. The malting of cereal grains involves the following steps:

a) choosing the grain and cleaning
b) 36 hours of steeping in cold water with two to three water changes
c) The grains are spread out on trays with wire mesh and allowed to germinate for three days. These pans are individually covered with water.
d) Kilning: On kilns, the germinated grains are slowly dried.

High levels of the enzyme alpha-amylase can be found in the flours of germinated cereals, which constitute the main component of amylase rich food (ARF). Because of their low-calorie and low-volume composition, ARF are great weaning foods. Malt is used in a wide variety of products, including brews, bakery goods, newborn formula, malted milk candies, and breakfast cereals.

1.6 COOKERY OR CEREALS

1.6.1. Gelatinisation-

Granules of starch will not dissolve quickly in cold water, but they will produce a temporary suspension; eventually, the starch will settle out. When soaked grains are cooked in liquid, they expand. This process is known as gelatinization.

1.6.2. Gluten Formation-

Although other cereals have a similar protein content, wheat's glutelin and gliadin content make it a good choice for some recipes. The protein that provides gluten its stiffness and rubberiness is known as glutenin or glutelin. Gliadin promotes adaptability. The dough can be rolled into chapathi or poori because to its pliability.

1.6.3. Dextrinisation-

Granules of starch are also altered by dry heat through a procedure called dextrinisation. Dry heat causes the formation of dextrins, which are carbohydrate substances. These taste pleasant after being dissolved in water. Changes in flavour and colour also take place. Significant dextrinization lessens the ability of starches to thicken liquids. Example- Toasted bread

1.7 BENEFITS OF CEREALS

1.7.1 Role of Cereals in Cookery

1. Cereals can be used to thicken liquids, such as corn flour in custard, white sauce, and macaroni soup.

2. Cereals are employed as a coating agent, such as bread crumbs or maida paste in cutlets.

3. Cereals are utilised in sweet dishes, such as wheat halwa and rice payasam.

4. Beverages and weaning mixtures can be made with malted grains.

5. Ready-to-eat foods include cereal items like corn flakes and rice flakes.

6. Cereal-based fermented meals, such as idli and dhokla, are consumed for breakfast or as snacks.

1.7.2 Health Benefits of Cereals-

1. Energy Source: Cereals are the main food group in the diet that provides energy.
2. High Mineral Content: Mineral and fibre content is high in ragi, millets, jowar, and bajra.
3. Cancer Prevention: Reduce the risk of breast cancer by eating whole wheat products.
4. Constipation Prevention: Cereals contain soluble and insoluble fibres such cellulose, pectin, and hemicellulose that can help prevent constipation. Thus, constipation is avoided.

5. Maintain Blood Sugar Level: The fibre in cereals slows the rate at which glucose is secreted from food, maintaining blood sugar levels.
6. Protein: Cereals typically include 6–12% protein.
7. Vitamin source: Cereals are an excellent source of vitamins B.

1.8 LET US SUM UP

The primary focus of this section was on the many facets of cereals, including in-depth descriptions of their structures and nutritional make-ups. This section includes examined important grains such as rice, wheat, and millets, as well as the primary products made from them and the benefits connected with them. The different forms of grain processing, including milling and parboiling, are covered in this unit, along with information on primary and secondary processing. This is because processing plays a vital part in the production of various cereal products. Following this, the item provides information regarding several methods of cooking grains, such as gelatinization, gluten production, and dextrinization. At the very conclusion of the lesson, you will find information about the benefits that cereals provide, either in the kitchen or for human health.

1.9 KEYWORDS

Rice Bran	The different forms of grain processing, including milling and parboiling, are covered in this unit, along with information on primary and secondary processing.
Breakfast Cereal	Other procedures, such rolling and baking to create flakes, could be used in the production. Consider wheat flakes.
Oats	Whole grains include oats. Because neither the bran nor the germ are removed, all oat products, including oat meal, oat flakes, and oat bran, are nutrient-rich.

Parboiling Parboiling is the practise of partially cooking rice inside of its husk.

Milling The main step is milling, which entails grinding the grain to make it conveniently cookable and produce appetising dishes.

Malting The conversion of cereal proteins and other macromolecules occurs as a result of the regulated germination process known as malting, which awakens the enzymes in the resting grain.

CHECK YOUR PROGRESS EXERCISE

1- Briefly explain the Structure of Cereal Grain.

………………………………………………………………………………
………………………………………………………………………………
………………………………

2- Write down a short note on "Nutritive Value of the Cereals".

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………………………………………………………………………………
………………………………

3- Briefly explain about the different processing methods for cereals.

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………………………………………………………………………………
………………………………

4- Write down about "Cookery of Cereals".

………………………………………………………………………………
………………………………………………………………………………
………………………………

Fill in the Blanks-

1. Cereals provides ……………………………..
2. The cereal's epidermis, or exterior layer, is made up of thin-walled, long, rectangular cells called………………………..
3. Bran is a good source of……………………………..
4. A process of addition of Vitamin and Minerals back to the cereal grains after milling process known as…………………..

State weather the statement is True or False-

1. Carbohydrates make up 80% of the dry matter of cereals.
2. Primary processing of whole cereal grains' major objective is to separate the grain's outer and interior layers.
3. Brown rice is a polished rice variety with a low fibre content.
4. Parboiling is the practise of partially cooking rice while it is still in its husk.

UNIT-6 FATS, OILS AND RELATED PRODUCTS

Structure-

1.0 OBJECTIVES

After finishing this lesson, students will be capable of:

- Know the Structure and Composition of Nuts and Oil Seeds
- Understanding the nutritive value of different Fats and Oil Products
- Select appropriate processes and preservation methods for Fats and Oils and manufacture Processed Fats and Oils with enhanced shelf-life.

1.1 INTRODUCTION- NUTS AND OIL SEEDS

Compared to carbs, fats have a more concentrated form of energy storage. They may be found in adipose (fatty) tissue from animals. The elements carbon, hydrogen, and oxygen make up oils and fats.

1.2 CHEMICAL COMPOSITION OF FATS AND OILS

Fatty acids and an alcohol, usually glycerol, combine to form the complex molecule known as fat. It is composed of carbon, hydrogen, and oxygen, however unlike carbohydrates, it contains a greater proportion of carbon, hydrogen, and less oxygen. It produces 9.1 calories per gramme of fat when it is oxidised, which is almost 14 times more than 1 gramme of carbohydrate.

A) **Classification of Fats (Lipids)**

There are three primary groups of fats:

1.2.1 Group-I

1. Simple Lipids

2. Compound Lipids

3. Derived Lipids

4. Unsaponifiable Lipids

1.2.2 Group-II

1. Saturated Fatty Acids

2. Unsaturated Fatty Acids

1.2.3 Group-III

1. Essential Fatty Acids

2. Non-Essential Fatty Acids

1.2.1 Group-I

1. **Simple Lipids**: Simple lipids are the neutral fats. Triglycerides make up the chemical structure of these. Three fatty acids and a glycerol base make up triglycerides. 98–99% of all food and body fats come from these "neutral fats."

2. **Compound Lipids**: These are made up of simple lipids that include protein, carbs, and phosphorus. Examples of similar ones are lipoproteins, glycolipids, and phospholipids. Because they help to build cell membranes and transport lipids in the blood, lipoproteins are crucial. Phospholipids and the nervous system are commonly linked (nerve tissue).

3. **Derived Lipids**: They are molecules that resemble fats and are produced from fatty substances. This category contains high amounts of glycerol and fatty acids.

- **Glycerol** about 10% of the fat is made up of. It is a neutral fat foundation or triglyceride that is water soluble.
- **Fatty acids** are the main subtypes of refined fuel fat that the cell uses to produce energy. They are the fundamental building blocks of fat and can be saturated or unsaturated. A few examples include oleic, linoleic, linolenic, arachidonic, palmitic, myristic, and stearic acids.

4. **Un-sapoifiable Lipids**: These consist of terpenoids, steroids, etc.

- Steroids: They are sterol-containing compounds that are associated to fat. Cholesterol is a crucial part of this group.

1.2.2 Group-II

1. Saturated Fatty Acids:

Saturated fatty acids are fatty acids with only one carbon atom connecting the molecules' carbon atoms. Because a fat has a large number of saturated fatty acids, it is solid at room temperature. Animal products such ice cream, whole milk cheese, cream, butter, meat, fish, and pig products, as well as margarine, vanaspati, and coconut oil made from whole milk., and so on include palmitic and stearic acids.

2. Unsaturated Fatty Acids:

A double or triple bond exists between the carbon atoms in the molecules of unsaturated fatty acids. A fat with more unsaturated fatty acids is liquid at room temperature.

Saturated fats make up the majority of animal fats, whereas unsaturated fats make up the majority of vegetable fats. Unsaturated fatty acids come in two different varieties:

A) Monounsaturated Fatty Acids (MUFA):

Given that it only contains one double bond, oleic acid is a mono-unsaturated fatty acid. On the other hand, because they contain two or three double bonds, linoleic and linolenic acids are PUFAs. Safflower, cottonseed, soyabean, corn, sunflower, groundnut, til, fish, salad dressing, and other vegetable oils include it.

B) <u>Polyunsaturated Fatty Acid (PUFA)</u>:

Examples include linolenic acid and linoleic acid (2 double bonds each) (3 double bonds). They assist with lowering blood cholesterol levels and coronary heart disease prevention. Vegetable oils like sunflower, peanut, soy, and corn oil contain PUFA.

1.2.3 <u>Group-III</u>

A Nutritional Classification of Fatty Acid is:

1. <u>Essential Fatty Acids</u>:

EFAs, which the body is unable to create on its own, must be received through diet. Linoleic acid, linolenic acid, and arachidonic acid are the three EFAs. The main dietary source of linoleic acid is vegetable oils.

2. <u>Non-Essential Fatty Acids</u>:

NEFAs are fatty acids that the body can make on its own and do not require dietary intake. Palmitic acid, oleic acid, and butyric acid are examples of NFAs.

1.3 SIGNIFICANCE OF FATS AND OILS

1.3.1 <u>Use of Fats in Food Preparation</u>

- Foods including meat, chicken, fish, dairy, eggs, nuts, and oil seeds naturally contain fat.
- Examples of fats made from fat found in natural sources include lard, cooking oils, salad oils, margarine, and butter.
- Fats have a high melting point despite the fact that they are solid at room temperature.
- Oils have a low melting point because they are a liquid at room temperature.

- In food items and cookery, it is used to flavour the food, as a frying medium, and as a shortening in the creation of biscuits, cakes, and other products.

1.3.2 **Nutritional Significance of Fats and Oils**

- energy source that is concentrated (9 kcal per gramme). It contains 2.25 times more energy per unit of weight than proteins and carbs.
- Limit the amount of mass you consume.
- a beneficial supply of the fat-soluble vitamins A, D, E, and K.
- contribute significantly to the production of certain long-chain fatty acids.
- Linoleic acid, an EFA, is a part of the membranes of living cells.
- Utilised to make prostaglandlin, a hormone vital for many crucial physiological activities, such as speeding up blood clotting and preventing coronary artery blockages.
- Slow exiting of the stomach and lance hinder digestion. Thus, hunger pangs are postponed.
- Digestibility ranges from 95 to 98 percent.
- The melting point influences digestibility (M.P)
    - Melting point – < 430C – completely digested
    - Melting point – > 430C – slowly digested.

1.4 PROCESSING OF FATS AND OILS

Processing of Fats and Oils-

Natural sources of fats and oils do not exist. present in fruit, plant seeds, and animal tissues. They are separated, purified, and processed for a particular use. removed fats from

- tissues from animals by rendering

Other sources by

- Extracting solvents and pressing

Production and Processing Methods

1.4.1 Plasticity:

At room temperature, the majority of fats and oils are made up of liquid oil and solid fat crystals. A network of small crystals holding the liquid component together enables fat to be moulded or compressed into different shapes without breaking. This trait of fat is referred to as plasticity. Oil can be used to cream plastic fats. The size and kind of crystals in plastic fat affect the performance of the fat in baked goods and pastries.

1.4.2 Hydrogenation-

The process of hydrogenation converts liquid oils to solid fats. Plant oils include a high amount of unsaturated fatty acids, which causes them to go rancid.

These oil's unsaturated glycerides can be converted to more saturated glycerides by the addition of hydrogen. This process is known as hydrogenation.

Vegetable oils are converted into hydrogenated fat by reacting hydrogen atoms with the double bonds in unsaturated fatty acids in the presence of a catalyst (finely divided nickel). A solid fat that has a higher melting point than the initial ingredient oil is the end result. Economically, hydrogenation is important because it enables the conversion of oils into fats with better storage qualities. The various vanaspati brands that are sold on the market are prepared using this method.

The final product's quality is determined by

- Temperature
- H2 mixing rate
- catalytic nature
- the force of H2

After the Hydrogenation Process-

- The fat will have no flavour.
- Therefore, a high smoking temperature will have good shortening power.
- High stability
- Low undesirable flavour

[Vansapathi- Vanaspathi is a hydrogenated oil composed of 95% hydrogenated oil and 5% liquid oil. Vanaspathi was traditionally made with sesame oil. Currently, non-traditional oils like as Vanaspathi are being used more frequently.]

1.4.3 Winterization:

The oils are rapidly chilled without stirring after steam deodorization to produce big crystals that may be filtered. Triglycerides with a high melting point and high molecular weight make up these crystals. Filtration is used to remove them, and the filtered, cold, viscous oil is what is known as "winterized."

Winterized oil does not become cloudy or solidify in the refrigerator. It can be used in foods that need to be refrigerated, including mayonnaise and salad dressings, which can still be poured when chilled. It is an important phase in the oil refining process. Olive oil is neither deodorised or winterized because these processes eliminate its flavour.

1.5 PRODUCTION AND PROCESSING METHODS FOR FATS AND OILS

Production and Processing Methods-

Animal, marine, and vegetable fats and oils can be produced using only a few basic techniques. These are followed by other refining and modifying procedures, such as rendering, solvent extraction, and pressure ejection.

1.5.1 Rendering

- Dry Rendering
- Wet Rendering

Heat is used to remove fat from animal tissues, and the minced and diced tissues are then covered with:

- Water (wet rendering)
- Without water (dry rendering)

a) <u>Wet Method</u>- Steam is employed in this technique. This procedure produces effective fat separation and good cell disintegration.

b) **<u>Dry Method</u>-** Steam is used to heat the tissue in vacuum containers.

c) **<u>Improved Method</u>**- fatty tissue fragmentation into tiny particles, followed by 15 seconds of flash heating. The item is then ground and centrifuged. This process produces a stable, bland, and high-yielding product.

1.5.2- <u>Pressing</u>:

This process is performed with a pestle and mortar. Lower oil efficiency. Natural flavouring and de-oiling make this cake suitable for animal feed.

1.5.3- <u>Solvent Extraction</u>:

This procedure is more effective than pressure extraction. Hexane is a common organic solvent used in solvent extraction.

1.5.4- <u>Refining</u>:

- The crude oil produced by the aforementioned techniques contains several impurities, such as free fatty acids (FAA), unsaporifiable matter, gums, waxes, mucilage, colouring matter, metallic contaminants, and unwanted odoriferous components, among others.
- Included in the refining process are the following procedures:
- The removal of suspended particles by filtering and centrifugation.
- FFA are eliminated with alkali treatment
- Under vacuum, deacidification and deodorization are achieved by passing steam through boiling oil.
- The remaining FFAs are eliminated using neutralisation.

- The removal of pigments by bleaching (activated 'C' or chemicals).
- Deodorisation is accomplished by injecting low-pressure steam through oil.

1.6 SPECIFIC FATS

1.6.1- Animal Fat

a) Butter:

Pasteurized cream that inactivates lipase and kills germs. Adding a starter to develop lactic acid affects the flavour. Cream agitated by the addition of H2O creates batter by coalescing fat globules and rupturing the protein envelope around each globule. Butter can be seasoned with salt. Example: emulsion of oil and water

b) Lard:

Pig's lard is an animal fat. It is made by rendering fatty tissues in heat. The location of the animal's fatty tissues and the heating technique affect how much lard is produced. Following Methods are utilized to delay the rancidity-

- Autoxidation
- Bleaching
- Homogenisation
- Deodorisation
- Adding emulsifiers

c) Margarine

By hydrogenating vegetable oils such soya bean, cotton seed, etc. and combinations of vegetable and animal fat, margarine is created as a replacement for butter. It is produced with whey or cultured pasteurised skim milk (SM) and one or more optional fat additives. To increase the nutritional value of the margarine, vitamin A and D can also be added. Additional components that may be used include

- Lactin Monoglycerdes
- fatty acids that produce fat
- Emulsifying substances
- synthetic colours
- Salt, citric acid, certain citrates, and sodium benzoate are all used as preservatives to a 0.1 percent concentration.

d) <u>Emulsions</u>

Emulsions are dispersion of one liquid in another liquid with which it is immiscible. It can be classified as-

<u>Temporary Emulsion</u>: Oil + water shaken together – but on standing oil particles separate from water. Example- French Dressing, Rasam Seasoned with Oil.

<u>Permanent Emulsions</u>- Apart from water and oil a 3rd substance called emulsifying agent or emulsifier is necessary to stabilize the emulsion. The following Stabilizer/ emulsifiers are used to develop permanent emulsion-

- Whole eggs,
- Egg yolks,
- Gelatin,
- Pectin,
- Starch paste,
- Casein,
- Albumin, and
- Fine powders like parika and mustard

<u>Examples of Permanent Emulsions</u>-

- Cake batter – egg, casein, gelatin, starch flour
- Sambar, kitchedi, payasam – proteins starch and oil
- Mayonnaise oil (liquid + lemon juice/vinegar (liquid + Egg yolk (lipo protein) emulsifying agent

1.6.2- <u>Vegetable Oils</u>

- Ground Nut oil
- Clear colored liquid
- Used exclusively in cooking
- Used in margarine preparation and vanaspathy
- Used to preserve fish tinned sardines

Other Oils

- Rape Seed / Mustard Oil- Used as edible oil and as a lamp oil
- Sesame Oil- Used as edible oil
- Coconut Oil- Used in the preparation of soaps, vanaspathy and margarine. Also used as edible oil
- Cotton Seed
- Sun Flower
- Soya Bean Oil- Can be used to get concentrated and isolated sources of protein
- Palm Oil- Rich in β-carotene.

1.7 SPOILAGE OF FATS AND OILS

1.7.1 Flavor Reversion

When refined oils are exposed to UV light, visible light, or heat, a flavour known as "flavour reversion" develops before rancidity takes hold. The reaction is catalysed by oxygen and minute amounts of metals like iron and copper. Nucleic acid-containing lipids are the most reversible. Soy bean oil is mostly impacted by flavour reversion.

Prevention of Flavour Reversion-

- Hydrogenation
- Reversion is avoided by adding a little amount of linolenic acid.
- use of metallic sequestrants or activators that bind to copper and iron to inhibit Flavour Basically reversion in soy oil

1.7.2 Rancidity

This deterioration mostly affects fats with a larger content of unsaturated fatty acids. It falls into the category of

a) Hydrolytic Rancidity

A particular enzyme that breaks down fat into free fatty acids (FFA) and glycerol is the main culprit behind hydrolytic rancidity. The main volatile fatty acids in butter, butyric and caproic acids, are what give butter its rancid flavour or odour and make it unpalatable. Stearic, palmitic, and other long-chain fatty acids do not cause rancidity until they are oxidised. Lipase, which catalyses trans fat hydrolysis and prevents hydrolytic rancidity, must be totally deactivated by heat. Rancidity can also be caused by the enzyme lipase, which is made by some microbes.

b) Oxidative Rancidity

Unsaturated oils exposed to air will spontaneously absorb oxygen, which is referred to as oxidative rancidity. It causes flavours to taste rancid or tallowy and is the most prevalent and major type of rancidity. It is brought on by the reaction of oxygen with unsaturated oils. Oxidative rancidity is unaffected by moisture or pollutants. Pure and refined oils can turn rancid when they are exposed to air. Oxidative rancidity is the result of a complicated chain reaction. Once the reaction starts, it continues continuously.

Characteristics of Rancidity

- Undesirable odour, flavour, colour, and consistency alterations
- Vitamins a and e become inactive.
- Dry foods like prepared cereals that only contain a modest amount of fat may suffer from oxidative rancidity.

Factors Leading To Rancidity and Reversion

1. **Temperature**: Fats and oils that are stored at high temperatures quickly develop off flavours and odours.

2. **Moisture**: Due to rancidity, low moisture levels in cereals, especially breakfast cereals, promote their deterioration (Presence of moisture leads rancidity). Hydrolytic rancidity is brought on by moisture in butter and oils. Old butter has a rancid odour because of the hydrolysis of butter fat to butyric acid by the enzyme lipase. The lipase enzyme is deactivated and the moisture from the butter is removed when it is cooked to generate clarified butter or pure ghee. Butter that has been clarified can be stored at room temperature without becoming bad.

3. **Air**: The shelf life of the fat or oil is significantly influenced by how much air is in contact with it.. When lipids are exposed to oxygen, they undergo auto oxidation or oxidative rancidity. With relatively little levels of oxygen, reversion occurs. Because of their enormous surface area, potato chips and salted almonds deteriorate faster.

4. **Light**: Both rancidity and reversion occur more quickly in the presence of light.

5. **Metals**: Metals are potent pro-oxidants, therefore their traces accelerate the growth of rancidity and reversion. Equipment used in the extraction and refinement of oil may be contaminated with metal. Rancidity can be accelerated by rust from steel machinery as well as residues of copper, lead, zinc, and tin.

6. **Degree of Unsaturation**: A crucial indicator of oxidative rancidity and reversion is this. Flavor reversion occurs in oils with high levels of unsaturated fatty acids and in shortenings made from such oils. High linolenic and linoleic acid content oils have the opposite reaction. Oils with unsaturated fatty acids get rancid.

7. **Absence of Antioxidants**: Oils that include antioxidants, whether naturally occurring or artificially added, prevent rancidity. Vegetable oils naturally contain vitamin E, commonly known as tocopherol, which functions as an antioxidant to stop oil oxidation. In order to stop rancidity, the antioxidant takes in oxygen and oxidises it.

<u>Prevention of Rancidity</u>

- Rancidity is prevented during storage in the refrigerator.

- Glass containers of a light colour absorb sunlight and prevent food from rotting.
- Rancidity is prevented by specific colours of green bottles, cora sheets, yellow translucent cellophane, and other materials.
- Vacuuming packaging is recommended.
- Natural dietary antioxidants including vitamin C, beta-carotene, and vitamin E.
- Citric acid, a synergist or sequestering agent, binds or chelates metals and inhibits oxidation.

1.8 UTILIZATION OF FATS AND OILS IN FOOD PREPARATION

1.8.1 Smoking Point

- The temperature at which smoke constantly emanates from the surface of fat is known as the smoking point. The smoke point is lowered during fat breakdown during frying because free fatty acids are produced. At temperatures too low for frying, fat that has been used frequently or for a lengthy period of time can start to smoke. Low-lying substances, like batter or flour, reduce the smoking point. The amount of fat surface exposed increases with decreasing smoke point. Additional drawbacks of smoking include:
- Fats heated in shallow wide pans with slightly sloping sides start smoking earlier than fats heated in smaller pans with vertical sides.
- The smoking point of soya, cotton seed, pea nut, and corn oils is 2300 degrees Celsius.
- The smoking point of hydrogenated fats is 221-2320 degrees Celsius.
- Shortenings with monoglyceride as an emulsifier smoke at a lower temperature of around 1760 degrees Celsius.

1.8.2 Changes in Fat on Heating

There are four basic ways that oil breaks down, and if the oils are stored for an extended period of time, all of these decrease the smoke point and operating temperature as well as the quality of the cooking.

a) Pyrolysis (Thermal Break Down)

Whether or not oil comes into contact with food, heating causes a breakdown in its molecular structure. When fat starts to smoke, it undergoes chemical breakdown, which produces free fatty acids and acrolein from glycerol. Acrolein causes eye and nose irritation when fat is smoked for any amount of time.

b) Oxidation

Hot oil surfaces reacting with oxygen in the air causes molecular disintegration and rancidity to occur.

c) Hydrolysis

Some of the water that is boiled off of the food when it is fried has the tendency to break down the oil.

d) Reaction with Food Residues-

After cooking, food pieces in oil undergo chemical reaction, especially if the oil is heated without removing leftovers. This kind of degradation can be minimised by straining oil after use.

1.9 IMPORTANCE OF FATS AND OILS

Importance of Fats and Oils

Fat Improves Texture-

Acts as a leavening agent in cookies, cakes, and biscuits; in cakes, the incorporation of oil creates walls surrounding each tiny bubble.

Fat as a Shortening Agent-

Due to the insoluble nature of baked goods in water, fat prevents the hydration and cohesiveness of gluten strands during mixing, shortening them and resulting in a more soft product.

Fats for Smoothness-

- Ice cream and other frozen sweets with fats have smaller crystals and a smoother texture.
- Fats, such as those found in halwa and candies, interfere with the crystallisation of sugar.
- Avoid lump formation as in Upma Mayonnaise emulsion produces smooth texture

Fats Enhances Flavour-

- Aromatic flavouring chemicals dissolve in fat, enhancing flavour. For example, onion, ginger, garlic, pepper, and so on.
- Fats, such as Ghee Fats, improve palatability in terms of taste, flavour, and palatability. Turmeric added to oil, for example, is dispersed uniformly in food.

Synergists-

Synergists are compounds that postpone auto-oxidation by enhancing the action of antioxidants. Citric acid, phosphoric acid, ascorbic acid, lecithin, and EDA, for example, react with pro-oxidant elements like copper and iron and render them useless.

1.10 LET US SUM UP

The unit discussed several different aspects of oils and fats. In addition to providing energy, fats and oils also shield the body from harmful substances. The course material included a discussion of the nutritional value of various fats and oils, including those derived from animals, nuts, and oil seeds (known as "Animal Fat" and "Vegetable Fat," respectively). Besides providing more energy than other macronutrients like carbs and protein, fats and oils are also needed for the absorption of fat-soluble vitamins such vitamins A, D, E, and K. The tool also facilitates research into new methods for enhancing fat and oil quality and preservation, such as hydrogenation. Spoilage of fats and oils, primarily in the form of rancidity, is also covered here. The section concludes with a discussion of the value of fats and oils in cooking and the human body.

1.11 KEYWORDS

Hydrogenation	Refined oils can be hydrogenated by passing H2 at high pressure through hot oil containing catalysts like nickel.
Emulsion	When one liquid is mixed with another that it is not miscible with, the result is an emulsion.
Flavour Reversion	When refined oils are subjected to ultraviolet (UV) light, visible light, or heat, they develop a rancid flavour known as "Flavor Reversion."
Smoking Point	The temperature at which smoke constantly emanates from the surface of fat is known as the smoking point.
Rancidity	Rancidity is a condition caused by the aerial oxidation of unsaturated fats found in foods and other items, and it is characterised by a disagreeable odour or flavour.

CHECK YOUR PROGRESS EXERCISE

1- Please explain what you mean by the phrase "Fats and Oils."

………………………………………………………………………………
………………………………………………………………………………
………………………………

2- Write down about “Processing of Fats and Oils”

…………………………………………………………………………………
…………………………………………………………………………………
………………………………

3- Write down a short note on “Rancidity”.

…………………………………………………………………………………
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………………………………

4- What do you understand by “Smoking Point”

…………………………………………………………………………………
…………………………………………………………………………………
………………………………

Fill in the Blanks-

1. The technique of forcing H2 through hot oil under pressure while using catalysts like nickel is referred to as…………………………………
2. …………………………..is the dispersion of one liquid into another that it cannot mix with.
3. Unsaturated oils exposed to air experience spontaneous oxygen uptake, which is known as…………………………..
4. The fat from animal tissues is drained by the process of heating, and then the chopped and minced tissues are covered with water to form what is known as…………………….

State weather the statement is True or False-

1. The temperature at which smoke constantly emanates from the surface of fat is referred to as the Smoking Point.
2. Fatty acids that are essential to the body are those that the body can produce on its own and do not require supplementation from the diet.
3. The development of rancid flavours and aromas in fats and oils is sped up by storing them at temperatures that are too high.

4. Simple lipids that contain phosphate, carbohydrates, and protein are referred to as derived lipids.

BLOCK-3 PROTEINS, ENZYMES AND MILK PRODUCTS

Understanding proteins is essential as they are fundamental molecules that play a crucial role in various biological processes. Proteins are versatile in nature and exhibit a wide range of structures and functions. The unique sequence of amino acids determines the protein's three-dimensional structure, which in turn determines its function. Proteins can be classified into several categories based on their structure, such as fibrous proteins (providing structural support) and globular proteins (performing enzymatic and regulatory functions). On the other hand, enzymes are protein in nature and are utilized for various purposes in food processing, such as tenderizing meat, developing flavors in cheese and fermented products, and modifying dough in baking. They play a key role in enhancing the sensory attributes, texture, and shelf life of food products. Milk products serve as fundamental ingredients in numerous food creations and require a deep understanding of their composition, functionality, and processing techniques. From formulating dairy-based products to creating emulsions and foams, milk products provide the basis for a wide range of food formulations. Additionally, knowledge of milk composition, heat stability, and quality evaluation is vital for ensuring the safety and overall quality of dairy products.

Unit- 7 focuses on '**protein'**. The classification, composition, non-enzymatic browning are discussed in detail in this unit.

Unit-8 contains information related to "**enzyme**." The nature of enzyme stability and action are discussed in this section. This course helps students build a greater understanding of the various enzymes used in food processing industries to enhance the sensory attributes of the end product.

Unit-9 includes "**milk and milk products**" in its scope of coverage. In this lesson, we will discuss the physical and functional properties of milk. This unit also helps make it easier to understand facts regarding denaturation and effect of processing and storage.

UNIT 7: PROTEIN: CLASSIFICATION, COMPOSITION, DENATURATION, NON ENZYMATIC BROWNING

7.9. Answer key

7.1. INTRODUCTION

In this unit you are going to learn about function, properties and composition of protein. You will also study the classification of protein on the basis of function, composition, shape and nutritional quality.

A detailed discussion will be done on structure of protein will be done to understand the mechanism of denaturation. In this you learnt about the browning reaction and its type (enzymatic and non-enzymatic browning). Lastly we will discuss about the role of these reactions for obtaining the desired quality of the food products and importance various enzymes in the food sector for the production of good quality of bakery, confectionary, milk and milk products etc.

Objectives

After studying this unit, you will be able to:

- Learn about the protein, its function &properties
- Comprehend the classification and composition of proteins
- Understand the denaturation process
- Learn the basic concept of enzymatic and non-enzymatic browning.

Protein was first found in animal and plant tissue as the complex nitrogenous organic compound and the term protein was first given by Mulder in 1838. On a dry basis, it accounts for approximately three-quarters of an animal's body. Muscles constitute about 50% protein, bones 20%, skin 10%, and the remaining amount is present in other parts of the body.They are necessary for all biological processes involved in life. Protein are the complex nitrogenous organic macromolecules. In addition to carbon, hydrogen and oxygen, they contain nitrogen. Sulphur and phosphorus were also found in most of the proteins. The simpler unit of protein is amino acid. The amino acids are joined by the peptide bond. There are about 20 amino acids.

In our body all the biochemical reaction are catalysed the enzymes. Proteins are an essential component of all structural tissue in the body, hence their significance for all facets of life cannot be overemphasised.

7.1.1. FUNCTION OF PROTEIN:

a) **Growth and maintenance of tissue:** For the development of muscles, a wide range of amino acids is required beyond the amount required for the maintenance and repair of existing tissue. Proteins are required for the crucial process such as cell division. The cytoskeleton (which is required for distributing the content and chromosomes that consist of genes during cell division) and intracellular scaffolding require specific proteins. About one-sixth of the total weight of moist cells consists of proteins.

   The innermost composition, or structural framework, of bones and teeth is made up of protein molecules. These proteins are termed collagen. It is the major protein in tendons and ligaments and also serves as intercellular material and holds the cells together. Actin and myosin are the two types of proteins that make up the contractile fibres of muscles. The process of muscle contraction is fueled by the hydrolysis of adenosine triphosphate.

   Protein turnover, which accounts for 0.3 to 0.4 percent of the body's protein, is a continuous process of protein breakdown and resynthesis. During the degradation of proteins, amino acids are released, which are utilised by the body. The skin, hair, and nails on the body's surface are regularly shed, and this causes protein loss. Additionally, protein is lost from the continually shed intestinal wall cells that are expelled as faeces. During the turnover, proteins are required to be replaced as well as synthesised in order to repair the damaged tissue.

b) **Formation of Important Body Components:** Proteins are the building blocks of enzymes, particularly those involved in digestion. Many of the hormones produced by various glands in the body are proteins or peptides, including growth hormone, insulin, and gastrin. Hormones govern cellular metabolic processes. In addition, they regulate several crucial biological processes, including reproduction. Tyrosine acts as a precursor for the epinephrine hormone. This hormone is released by the adrenal gland. For thyroxine and cortisol, glycoproteins have a specific binding role.

Haemoglobin, a protein, transports oxygen molecules through the blood in order to oxidise food molecules during respiration. Proteins make up the majority of the components (fibrinogen – helps in clotting). The eye's photoreceptors, which trigger the nerve signals necessary for the sense of vision when they absorb light, are made of proteins. Tryptophan is a key precursor to serotonin, a neurotransmitter that is important in relaying nerve signals from one nerve cell to another, and the vitamin niacin.

c) **Nutrients transportation:** Proteins are important for the movement of nutrients from the colon through the intestinal wall to the blood, from the blood to the body's tissues, and through the cell membranes of the tissues. These membrane-bound carriers and transporters are often specialised for a single nutrient; for example, retinol-binding proteins are required for the transport of only retinol, whereas some proteins like metallothione can transport zinc and copper ions. Various lipid molecules can be transported by lipoproteins.

d) **Regulation of Water Balance:** Both intracellular and extracellular compartments contain fluid in the body. The intravascular (inside the blood vessels) and intercellular (between the cells) compartments make up the extracellular space. Dissolved proteins and dissolved ions (electrolytes), principally sodium (Na^+) and potassium ions (K^+), maintain equilibrium between the compartments. Large blood protein molecules that cannot move from the blood into the intercellular space induce an oncotic pressure that draws water from the intercellular space and brings it back into the blood.

Due to the continuous pumping activity of the heart, it exerts a hydrostatic pressure that pushes fluid in the reverse direction, out of the blood and into the intercellular space. When there is not enough protein in the blood, hydrostatic pressure takes over and forces fluid out of the blood, leading to the retention of fluid in the tissues, resulting in oedema.

e) **Maintenance of Appropriate pH:** Acids and bases are continuously produced by physiological processes in the body and must be transported to the excretory organs via the blood. Alkalosis or acidosis can be fatal. The blood's proteins act as a buffer. If either of these factors affecting pH rises in concentration, they can combine with hydrogen ions and hydroxide ions.

f) **Defense and Detoxification:** The immune system, which produces protective proteins called antibodies, fights against infections. For a specific antigen, a specific antibody is needed. The body manufactures antibodies quickly when necessary. Enzymes, mostly located in the liver, detoxify the poisons found in food by converting them into harmless compounds.

g) **Source of Energy:** Like carbohydrates, proteins are only used as an energy source when the diet is deficient in both carbohydrates and fat. Protein can provide 4 kcal of energy per gm which is equivalent to that of carbohydrate.

7.1.2. PROPERTIES OF PROTEINS

a) **Amphoteric Nature**

Proteins are considered ampholites as they can serve as both acids and bases, like amino acids. Under an electric field, the protein molecules move because they possess electric charges. The pathway of motion is determined by the overall charge on the protein molecule. The protein's isoelectric point is the pH at which the overall charge on the protein molecule is equal to zero.

b) **Solubility**

Each protein dissolves to a different extent in a solution with a particular salt concentration and pH. Unlike globulins, which are almost insoluble in water but soluble in neutral sodium chloride solutions, albumin can be dissolved in water only. Some proteins, like casein, are soluble at an alkaline pH. Based on their solubility, proteins can be separated from the mixture.

c) **Colloidal Nature**

Proteins are macromolecules with a higher molecular weight. They generally form colloidal solutions and are therefore impermeable to semi-permeable membranes. This unique property of proteins has substantial physiological significance.

7.1.3. CHEMICAL COMPOSITION

Amino acid molecules are the fundamental building block of every protein. In order to create proteins, around 20 different amino acids are required. All amino acids are made up of the atoms of carbon, hydrogen, oxygen, and nitrogen. The exceptions to this rule are cysteine and methionine, which also contain sulphur atoms. Every amino acid has a central carbon atom to which are connected an amino group (NH2), a carboxyl group (COOH), and a hydrogen atom (H), which is also attached to the side chain or side of the amino acid. The basic structure of an amino acid is shown in Figure 1.

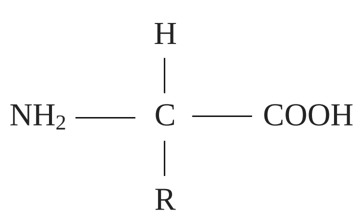


Figure 1: General structure of amino acid

The essential or indispensable amino acid are the amino acid must be obtained through diet because our body is unable to produce enough of them its own. Those amino acid that are produced by our body are called as non-essential or dispensable amino acid. The essential amino acids are leucine, isoleucine, lysine, tryptophan, methionine, phenylalanine, histidine, threonine and valine. Arginine, tyrosine, cysteine, glycine and serine act as a semi essential amino acids. The remaining amino acids are dispensable amino acid.

Table 1.1 Essential amino acid in different food groups

	Food group	**Limited amino acid**
1.	Cereal	Lysine and threonine
2.	Pulses and legumes	Tryptophan
3.	Oilseed and nuts: Sesame seed Groundnut seed Coconut	 Lysine Lysine, threonine, methionine Lysine, threonine, methionine (lesser extent than groundnut)
4.	Egg	-
5.	Milk and milk products	Sulphur amino acid
6.	Meat fish	Sulphur amino acid -

7.2. CLASSIFICATION OF PROTEINS

Protein can be classified on the basis of the following parameter:

- Function
- Structure
- Composition
- Nutritional Significance (based on quality)

7.2.1 CLASSIFICATION ON THE BASIS OF FUNCTION

1) Catalytic protein: Protein acting as biocatalyst such as lactase, glucose oxidase etc.
2) Storage protein : Casein
3) Transport protein: Certain protein acts as a transporter (carry molecules). Haemoglobin and lipoprotein are the good example of transport protein.
4) Protective protein: antibody is a protein which is released the body against the foreign organism. Examples of protective protein are Immunoglobin, Fibrinogen etc.
5) Contractile protein: Required for the contraction and relaxation of muscle (Actin and myosin).
6) Structural protein: it forms the skeleton or framework that gives mechanical support for example, elastin, keratin and collagen
7) Hormonal protein: some of the hormones are protein in nature (pancreatic hormone).
8) Receptor protein: chemoreceptor and rhodopsin
9) Regulatory protein: regulate the processes such as histone protein essential for DNA stabilization.

7.2.2. CLASSIFICATION ON THE BASIS OF STRUCTURE

1. **Globular protein:** They are spherical proteins that are soluble in water. Catalytic, transport, and protective proteins are globular proteins. They are also known as spheroproteins. It contains hydrophobic parts (inside the sphere) and hydrophilic parts (on the surface of the sphere).
2. **Fibrous protein:** they are long fibers or larger sheets, mainly consist of long polypeptide chain. It is insoluble in water and contain hydrophobic part. Structural and protective protein such as collagen, keratin etc. are the example of fibrous protein. They are known as scleroproteins.

7.2.3. CLASSIFICATION ON THE BASIS OF COMPOSITION

1. **Simple Proteins** – Proteins which on hydrolysis give only amino acids. Simple proteins can be classified into seven classes which are as follows:

    1. **Albumins:** Albumins are soluble in pure water and can coagulate when heated. Examples include blood serum albumin and egg albumin.
    2. **Globulins:** Globulins, on the other hand, are soluble in neutral NaCl solutions but insoluble in pure water. Serum globulin, tuberin (potato), arachin and conarachin (peanuts) are a few examples.
    3. **Glutelins:** Glutelins are insoluble in all neutral solvents, although they are soluble in extremely diluted acids and alkalis. The protein in this class that is most well-known is wheat glutenin.
    4. **Prolamins:** 70–80% of alcohol can dissolve prolamines. For examples are zein (maize), hordein (barley), amadin (almonds) and gliadin (wheat).
    5. **Fibrous proteins:** Proteins that are typical of animal skeletons and also serve as external defences, such as skin and hair. Collagen, elastin, and keratin are best examples.
    6. **Histones:** They are soluble in water but insoluble in diluted ammonia. They produce a variety of amino acids upon hydrolysis, consisting mainly of basic amino acids. Thymus histones and globin are the most significant members.
    7. **Protamins:** They are strongly basic proteins of low molecular weight. It is soluble in water and resists coagulation by heat. It also yields significant amounts of basic amino acids upon hydrolysis. Salmin from salmon sperm is one of the protamins.

2. **Conjugated Protein:** When a protein molecule is attached to another molecule other than the protein, it is called a "conjugated protein."

    a) **Nucleoprotein:** Proteins that contain nucleic acid are called nucleoproteins.
    b) **Glycoproteins:** Glycoproteins, on the other hand, are proteins that have a carbohydrate group attached to them. For instance, mucins.

c) **Phosphoproteins:** Proteins that contain phosphorus bound to the protein molecule are known as phosphoproteins. ovovitelin (egg yolk) and caseinogen (milk) are two examples.

d) **Haemoglobin:** Protein molecules bound to the haem.

e) **Lecithoproteins:** Protein molecules that have been coupled with lecithin or other similar compounds.

3. Derived Proteins

A. **Primary Protein Derivatives:** Derivatives of the protein molecule that are partially produced through hydrolytic reactions and only undergo minor modifications. It includes metaproteins and coagulated protein.

B. **Secondary Protein Derivatives:** They are obtained further hydrolytic breakdown of the protein molecule.

a) **Proteoses,** which may be dissolved in water but cannot coagulate under heat, must have their solutions saturated with ammonium sulphate in order to precipitate them.

b) **Peptones,** which are soluble in water but not coagulable by heat or precipitated when their solutions are saturated with ammonium sulphate. These are obtained by further degradation of proteoses.

c) **Peptides** are molecules made up of two or more amino acids. The terms "dipeptide," "tripeptide," and "polypeptide" are used to describe anhydrides of different numbers of amino acids. The peptones are further hydrolyzed, and the end product is a peptide.

7.2.4. CLASSIFICATION ON THE BASIS OF NUTRITIONAL SIGNIFICANCE

1. **Complete protein:** Proteins that contain all the essential amino acids. Example: egg protein.

2. **Partially complete protein:** Protein that is deficient in one or more essential amino acids, for example, wheat protein.
3. **Incomplete protein:** Protein that is completely deficient in one or more essential amino acids. Examples of incomplete proteins are gelatin and zein

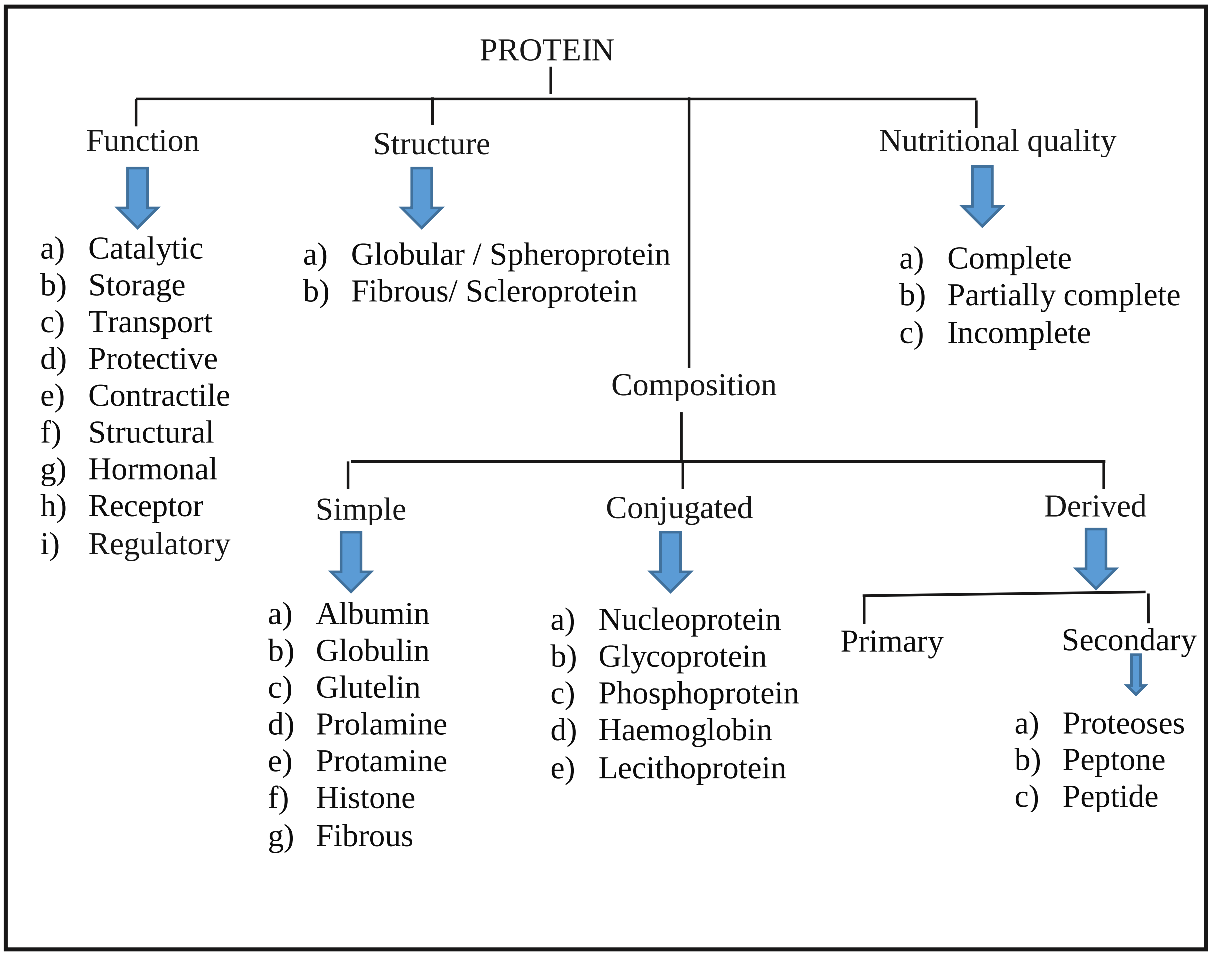


Figure 1: Classification of protein at a Glance

7.3. STRUCTURE OF PROTEINS

Protein molecules have a unique three-dimensional structure. Proteins are macromolecules that are formed by combining various amino acids. We have discussed the basic structure of amino acids in the previous section. Hofmeister and Emil Fisher suggested independently in 1920 that amino acids are linked via a peptide bond. Proteins exist in different conformations, namely primary, secondary, tertiary, and quaternary.

7.3.1. Primary Structure:

The peptide bond, which results from the interaction between an amino acid and a carboxyl group as shown in Figure, is the primary method of linking amino acids in proteins.

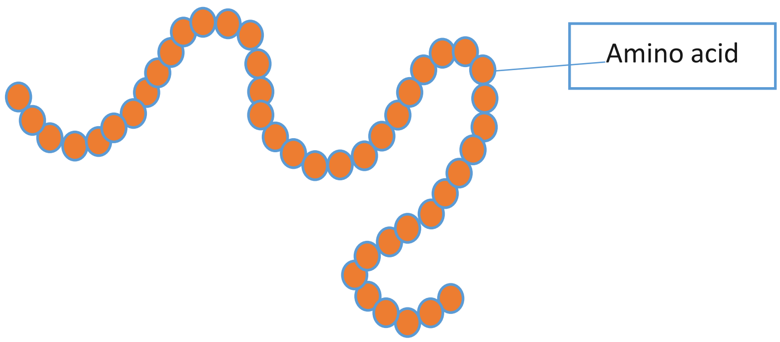
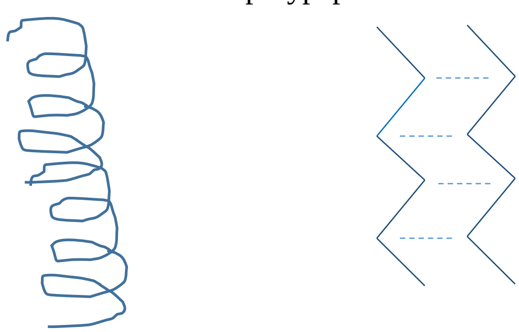


Figure 2: Primary Structure of Protein

7.3.2. Secondary Structure:

In the secondary structure of proteins, regular folding occurs, resulting in a coiled polypeptide chain. The carboxyl and amide groups of the peptide chain are linked together by hydrogen bonds, which accounts for the majority of the folding. On the basis of hydrogen bonding, the secondary structure can be α helix or β pleated sheet.

When the hydrogen bonds form within the same polypeptide chain, it results in α helix structure of the protein. The β pleated sheet will be developed if the hydrogen bonds form between two polypeptide chains.



a) α helix b) β pleated sheet

Figure 3: Secondary Structure of protein

7.3.3. Tertiary Structure:

The protein molecule will have a lengthy alpha helix with a larger length-to-cross-sectional ratio (axial ratio). Physical measurements show that many proteins are spherical.

Hence, the helical arrangement must be disrupted occasionally, leading to the formation of multiple bonds with extra folding. Covalent or other bonding is required to preserve this unique three-dimensional structure. In some molecules, covalent disulphide bonds are formed. However, in many globular proteins, additional types of bonds like hydrogen bonds, salt bonds, and hydrophobic or non-polar bonds are formed instead of disulphide bonds.

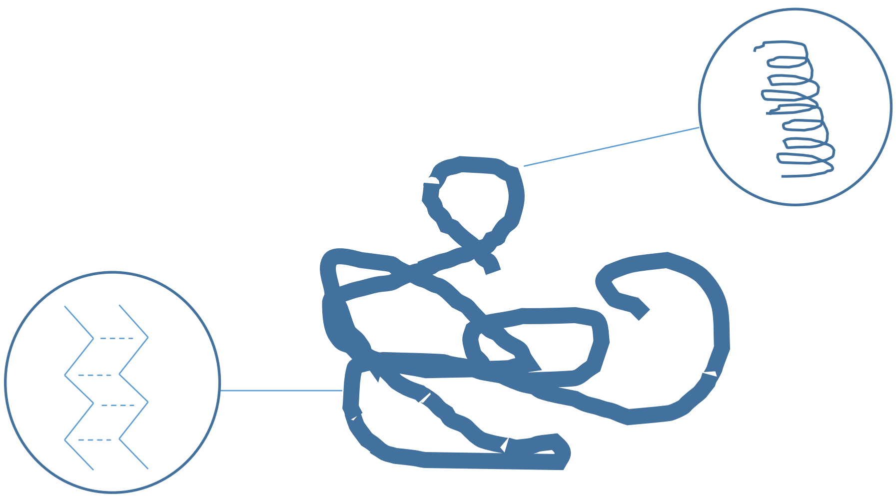


Figure 4: Tertiary Structure of protein

7.3.4. Quaternary Structure:

Apart from primary, secondary, and tertiary structures, some proteins exhibit a fourth level of organisation in which multiple monomeric units unite. These monomeric units have relevant primary, secondary, or tertiary structures. The monomeric subunits can be similar or different, depending on the enzyme activity.

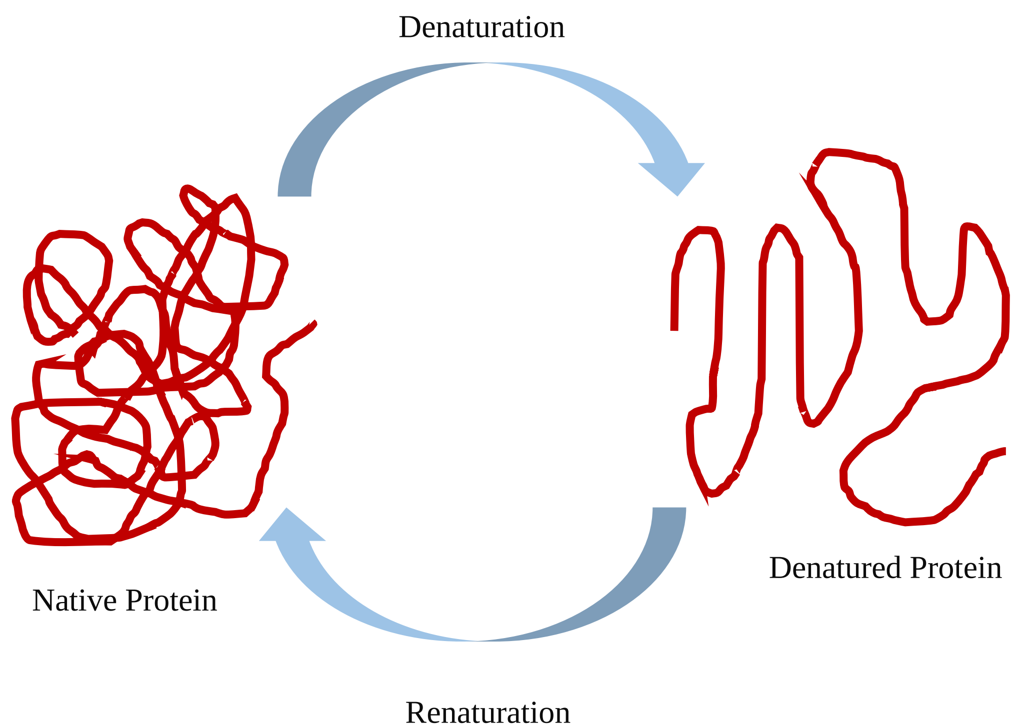
Figure 5: Quaternary Structure of protein

7.4. DENATURATION

Proteins that are naturally present in both plant and animal tissues are termed **native proteins**. Primarily these native protein possess peculiar properties such as viscosity, electrophoretic mobility, solubility etc. When these native proteins are exposed to UV radiation, heat, salt, acid or alkali treatment, etc., they experience denaturation, which results in changes to their physical characteristics.

Denaturation of proteins can be reversible or irreversible. Reversible denaturation involves minor protein alteration, which can be reversed by the use of appropriate treatments. Irreversible denaturation includes permanent and irreversible changes that cannot be restored as the unfolding of the molecule occurs. Consequently, we may state that the following conditions can cause proteins to undergo denaturation:

- Exposed to alkali, acid and salt
- UV radiation
- Change in the temperature
- Mechanical agitation



7.4.1. Mechanism

Foremost step in denaturation process entails the cleavage of weak hydrogen bonds resulting in the unfolding of the complex molecule. Due to the unfolding of the protein molecule, the R group is free to form a bond with the subsequent R group, thereby causing the aggregation and hence the viscosity increases. This structural modification marks the first phase in the denaturation of proteins. Initially, protein molecules appear as sol, but when an adequate amount of proteins is combined, they get coagulated and make a gel in the second phase. In the third phase, the protein is termed precipitated or flocculated as the water escapes from the coagulated protein.

The consequences of denaturation of protein are as follows:

- The solubility of the denatured protein is decreased.
- They are easily digested by the proteolytic enzymes for example cooked food are easily digestible in spite of raw food.
- When the food is cooked, it is more easily digestible than the raw food because proteins get denatured by the heat treatment, and proteolytic enzymes can easily digest the denatured proteins.
- The denatured protein loses its biological activity and crystallization property.
- The structural alteration leads to increase in the viscosity of food.
- Flavour and texture is enhanced in heat denaturation.

7.4.2. Components affecting the denaturation of protein

pH – The amino acid possess the ionic property due to the presence of both hydrophilic and hydrophobic part. Depending upon the pH of the medium the free amino and carboxyl group develops the net charge. As we all know that proteins are amphoteric in nature as they can react with acid as well as with bases. The pH at which there is no net movement due to the neutralization of charge on the protein molecule is termed as isoelectric point. Curdling is likely to happen when protein in food reaches to its isoelectric Point.

Heat - When egg white is heated at 60°C, the protein ovalbumin gets denatured. As temperature increases, coagulation takes place and egg white separates out as a solid.

7.5. BROWNING REACTION

During the preparation, processing, and storage of food, changes in the colour, flavour, and aroma of food items occur to varying degrees, which is termed "browning". The composition of food and degree of reaction is responsible for these changes. It may be desirable or undesirable.

In certain dishes, browning results in a dark colour and special flavour that is highly preferable and directly linked to the product quality; for example, bread's browned crust, roasted coffee beans, nuts, and certain processed and baked items. Dehydrated foods like milk, sliced fruits, eggs, dry fruits, citrus fruit juices and juice concentrates, and canned milk all exhibit undesirable repercussions (off flavour and off odour) due to the browning reaction. In order to obtain the desired changes, browning should be carried out in a controlled manner. Browning reactions can be of two types: enzymatic and non-enzymatic as shown in Fig 6.

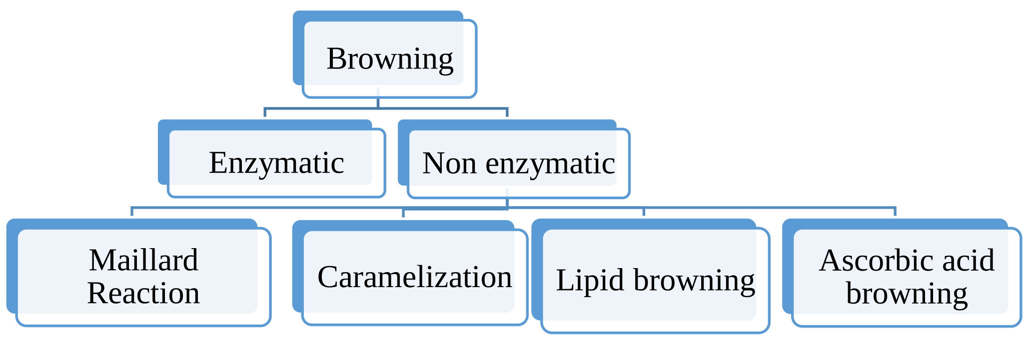


Figure 6: Classification of Browning reactions

7.5.1. Enzymatic Browning:

The colour of fruits and vegetables turned dark when they came into contact with air. This happens due to the presence of oxidative enzymes, which remain active and induce the oxidation of polyphenols. This occurs in fruits and vegetables which contain polyphenol or any phenolic compounds. The oxidase enzyme act on these polyphenols (substrate) and oxidized them to O-quinone (ortho-quinone), which readily polymerized to form brown pigments.

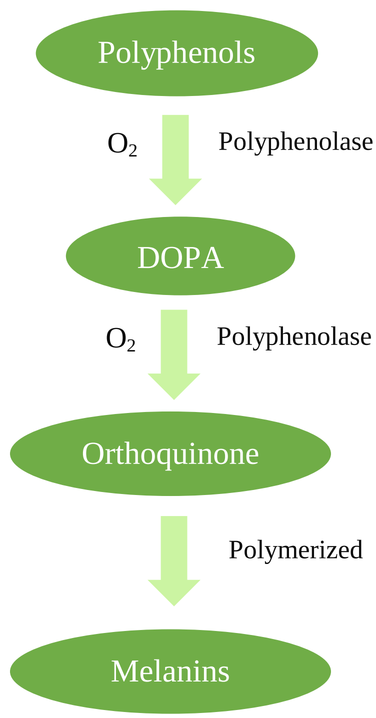


Figure 7: Enzymatic Browning

7.5.2. Non Enzymatic Browning:

7.5.2.1. Maillard Reaction: It was initially described by Maillard in 1912 as the formation of brown colour in a mixture containing reducing sugar and amino acids. This brown colour gives a distinctive colour, flavour and aroma to the different food products. This includes the series of reactions in which the amino group of the protein molecule condenses with reducing sugar to form an intermediate product that undergoes rearrangement (Amadori Rearrangement). Further dehydration, degradation and polymerization occur, leading to the formation of brown pigments.

These reactions are favoured by the following parameters:

- **Temperature**: The rate of browning escalates with an increase in temperature.
- **pH value:** browning increases with an increase in pH. The browning process is speed up by the buffer salts phosphate, citrate, and acetate.
- **Type of amino acid and sugar:** The highest effect is observed in lysine, followed by tryptophan and arginine, among all the amino acids. Glucose has a strong affinity to react with lysine as compared to fructose and lactose, whereas lactose has a strong affinity to react quickly with tryptophan.
- **Catalyst:** These reactions are catalysed in the presence of metal ions (iron, copper, and phosphate ions).
- **Moisture content:** The reaction rate was reduced at very low or high water levels. Approximately 13 per cent of moisture content is required for the reaction to take place.

Browning reaction can be controlled by decreasing the pH and temperature during the processing and storage. Loss of nutrients occurs during the reaction.

7.5.2.2. Caramelization:

When sugar is heated above its melting point, it melts and transforms into a liquid state. Numerous decompositional changes take place when sugar is exposed to heat above its melting point. On continuous heating, this clear liquid slowly changes to a brown colour. At approximately 170 °C, as caramelization takes place, a distinctive caramel flavour develops along with the brown colour. Caramel obtained has a bitter or pungent taste and lesse sweeter than the sugar.

Factors affecting the rate of browning

Temperature: A higher temperature is required for caramelization. The temperature at which caramelization occurs varies with the type of sugar involved in the reaction.

Type of sugar: Browning occurs rapidly in fructose as compared to maltose, galactose and sucrose. It slowly occurs in glucose.

Table 1.2 caramelization temperature of different sugar

Type of sugar	Caramelization temperature
Fructose	110 °C
Maltose	180 °C
Galactose	170 °C

pH: Browning increases with the presence of acid or alkali.

Catalyst: The presence of iron and copper increases the rate of browning.

7.5.2.3. Ascorbic acid browning:

Fruits rich in ascorbic acid undergo oxidation, leading to discoloration and the formation of brown pigment. Anthocyanin (the red pigment) degraded quickly in the presence of oxidised ascorbic acid, giving a pale brown colour to the product. Ascorbic browning is enhanced by a high pH, the presence of oxygen, reducing sugar, a high temperature, etc. This type of browning is observed in fruit juices and squash, which can be prevented by the addition of bisulfite or storing at a low temperature.

7.5.2.4. Lipid browning:

It is a rare, undesirable change that mainly occurs in fatty foods that are stored for a longer period of time.

7.6. let us sum up

Protein are the complex macronutrient that is required for building and repairmen of tissue. The building block or simpler monomeric unit of protein is called amino acids. These amino acids are link together via peptide linkage there are about 20 amino acids that categorized as essential and non-essential amino acids. The essential or indispensable amino acid are the amino acid must be obtained through diet because our body is unable to produce enough of them its own. Those amino acid that are produced by our body are called as non-essential or dispensable amino acid. The essential amino acids are leucine, isoleucine, lysine, tryptophan, methionine, phenylalanine, histidine, threonine and valine. Arginine, tyrosine, cysteine, glycine and serine act as a semi essential amino acids. The remaining amino acids are dispensable amino acid. Cereal is a staple diet of India as majority of people of all income group diets include cereal as main food group. Most of the cereal lacks in lysine and threonine. In addition to this, some cereal crops like maize are also deficient in tryptophan. Pulses and legume are the rich in lysine and threonine but lacks tryptophan. Egg contains all essential amino acids whereas milk and milk products, meat and meat products are limited in sulphur containing amino acids to a little extent.

Protein can be classified on the basis of function, shape, composition and nutritional quality. The unfolding of the tertiary and quaternary structure of protein results in denaturation of protein. The factor responsible for the denaturation are exposure to alkali, acid and salt, UV radiation, Change in the temperature or any mechanical agitation. These temporary changes can be restored by the process known as renaturation in the reversible denaturation. The irreversible denaturation includes the breaking of covalent bonds and are permanent.

During the preparation, processing, and storage of food, changes in the colour, flavour, and aroma of food items occur to varying degrees, which is termed "browning". The composition of food and degree of reaction is responsible for these changes. It may be desirable or undesirable. The non-enzymatic browning can be affected by temperature, pH value**,** catalyst, moisture content, type of amino acid and sugar. Caramelization, ascorbic acid browning, lipid browning are the example of non-enzymatic browning.

7.7. Glossary

Protein – complex macronutrient, building block of the body helps in the repairmen of the tissue. It can be obtain from the animal or plant sources such as milk and milk products, meat, fish, egg, pulses and legumes etc.

Amino acid – simpler or monomeric unit of protein. There are about 20 amino acid which can be categorized as essential amino acid and non-essential amino acid.

Denaturation: unfolding of the tertiary and quaternary structure of protein results in denaturation of protein.

Reversible denaturation: Temporary and changes can be restored process of renaturation

Isoelectric point: The isoelectric point (pI) is the pH at which a molecule or a particle has a net charge of zero. It is the pH at which the molecule or particle carries no positive or negative charge and is electrically neutral.

Globular protein: compact, spherical and soluble in water.

Fibrous protein: have long, rod like structure and insoluble in water.

Simple Proteins: Made up of only amino acids.

Histones: They are basic protein that help to organize and package DNA in the nucleus of the cell

7.8. Check your progress exercise

Fill in the blanks:

a) The term protein was first given by …………...
b) ………………….a protein, transports oxygen molecules through the blood
c) Casein are soluble at an …………… pH.
d) The building blocks of proteins are…………………….
e) The pH at which amino acid has no net charge is called……………….
f) The first amino acid isolated was…………………
g) When a protein molecule is attached to another molecule other than the protein, it is called a …………………….
h) …………………….. forms the skeleton or framework that gives mechanical support.

i) Proteins that contain phosphorus bound to the protein molecule are known as ………………

j) The Prolamins present in maize is…………………….

k) Irreversible denaturation includes…………………. modification.

l) The solubility of the denatured protein is …………………

m) The pH at which there is no net movement due to the neutralization of charge on the protein molecule is termed as …………………

n) The denatured protein loses its ………………………… and crystallization property

o) The structural alteration leads to ………………….. in the viscosity of food

p) ………………………….. degraded quickly in the presence of oxidised ascorbic acid, giving a pale brown colour to the product.

q) Approximately ………………………… of moisture content is required for the maillard reaction to take place

r) The browning …………………….. with an increase in pH.

s) The browning in fruit juices and squash can be prevented by the addition of …………………or storing at a low temperature.

Multiple choice question:

1. The amino acids of protein are linked with one another through ………..…. Bonds.
   a) Cystic
   b) Elastin
   c) Melittin
   d) Peptide
2. Stable arrangement of amino acid residues give rise and twisted resulting in α-helix or pleated is a ……………………………………….
   a) Tertiary structure
   b) Secondary structure
   c) Primary structure
   d) None of these

3. In the beta sheet of secondary structure, polypeptide chain proceed in the same direction amino to carboxyl is ………………………….
   a) Antiparallel
   b) Horizontal
   c) Parallel
   d) Antihorizontal
4. The amino acid sequence of protein in a polypeptide chain is known as …………………….
   a) Primary structure
   b) Tertiary structure
   c) Secondary structure
   d) Quaternary structure
5. The partial or complete disorganization of a protein's three-dimensional shape is called…………………..
   a) Renaturation
   b) Denaturation
   c) Both a and b
   d) None of these

Short answer type question:

1. Define protein and briefly explain the function of protein

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2. State the properties of proteins.

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3. State the difference between fibrous and globular protein.

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4. Classify the protein on the basis of composition.

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5. Discuss the structure of protein in detail with the help of diagram.

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6. Define denaturation. Briefly discuss the mechanism of denaturation.

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7. State the consequences of denaturation of protein.

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8. Mention the components affecting the denaturation of protein.

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9. What do you understand by the browning reaction?

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10. Explain the mechanism of enzymatic browning.

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11. Mention the parameter favouring the maillard reaction.

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12. Define the following terms:

a) Ascorbic acid browning

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b) Lipid browning

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Exercise 1

Fill in the blanks:

a) Mulder
b) Haemoglobin
c) Alkaline
d) Amino acid
e) Isoelectric point
f) Asparagine
g) Conjugated Protein
h) Structural protein.
i) Phosphoprotein
j) Zein
k) Permanent
l) decreased
m) Isoelectric point
n) biological activity
o) Increase
p) anthocyanin
q) 13 %

r) increase
s) Bisulphites

Multiple choice question:

1. d) Peptide
2. b) Secondary structure
3. c) Parallel
4. a) Primary structure
5. b) Denaturation

UNIT 8- ENZYME: NATURE OF ENZYME STABILITY AND ACTION, PROTEOLYTIC ENZYME OXIDASES, LIPASES, IMMOBILIZED ENZYMES

8.1. Introduction

In this previous unit we have discussed about the protein and learnt that protein had catalytic activity as it can speed up the reaction. So in this unit you learn about the enzyme, its property, nomenclature and classification. You will also study the about the factors that going to affect the catalysis of enzymes i.e. how these enzymes are influenced by different parameters such as temperature, substrate concentration, enzyme concentration, pH and other factors.

A detailed discussion will be done on Enzyme Inhibition, Competitive and Non-competitive inhibition and Enzyme inhibitors. In this unit, we will discuss about the application of Enzyme and importance of different enzyme such as Carbohydrases, Oxidoreductases (Glucose oxidase, Peroxidases, Ascorbic oxidase, Lipoxygenases), Proteases and Lipases in food processing unit. Lastly, we will learn about the Immobilized enzymes and types of enzyme immobilization technique.

Objectives

You will be able to:

- Examine the history, nomenclature and classification of enzymes.
- Comprehend the factors that the effect the enzyme activity.
- Learn about the enzyme inhibitors.
- Understand the immobilized enzymes and various technique used for immobilization of enzyme.
- Learn about its application in food processing industries.

A substance that turned starch into sugar was discovered by Payne and Persoz in an alcohol precipitate of a malt extract in 1833. This enzyme was the first to be discovered, and it was given the name diastase. In 1850, Louis Pasteur noticed that ferments (later referred to as enzymes), which are always connected with the yeast cells, catalyse the fermentation of sugar into ethanol by yeast. The word "enzyme" was first coined by W.F. Kuhne in 1876 and is derived from the Greek word Zymos, which means to leaven. Enzyme act as biological catalysts that changes the speed of a chemical reaction without contributing to its end products. Since ancient times, food has been altered with the help of enzymes in a number of desired ways. Traditionally, people have utilised methods like making alcoholic beverages with yeast, brewing with malted barley, and wrapping meat in the crushed leaves of papaya trees to make it softer. Enzymes have been utilised in the production of cheese and bread for countless generations. Enzymes are used by people without understanding its nature and reaction concerned. The nature of enzymes can be prove fruitful in food industry.

Plants and animals' tissue contain numerous enzymes, while most cellular enzymes are bound to subcellular organelles, some are found free in the cytosol. While some subcellular enzymes are specific to the organelle, others can be found in various subcellular and tissue locations, where they can catalyse the same reaction.

We need definitions for some terminology used frequently in enzyme research. Proteins having catalytic capabilities (speeding up the reaction) are referred to as "enzymes." The non-protein molecules that help some enzymes in their catalytic functions are known as cofactors. These cofactors can be organic (Coenzymes) or inorganic (Mg^{2+},Fe^{2+}, Zn^{2+}, Cu^{+}, K^{+}, Mn^{2+}etc). The term "holoenzyme" refers to the entire active enzyme that includes both the protein and the cofactor. The protein portion of holoenzyme is termed apoenzyme. The term "substrate" refers to the substance on which enzymes act. The different forms of enzymes of a particular species are called isoenzymes or isozymes. They are obtained from different genes but catalysed the same reactions.

8.2 Nomenclature and Classification

The first Enzyme Commission created a framework for categorising enzymes in 1961 that also serves as the foundation for allocating code numbers to enzymes. These code numbers have "EC" prefixes and consist of various elements with different meanings. There are about six classes of enzymes based on the reactions that they catalyse.

- **Oxidoreductases:** An oxidoreductase is a type of enzyme that facilitates the transfer of electrons from one form of a molecule (also known as the electron donor) to the other (also known as the electron receiver). In other words, we can say that it catalysed the oxidation and reduction reactions, for example, the dehydrogenase enzyme.

$$AH+B \rightarrow A+BH$$

Oxidation

$$Fe^{2+} + Cu^{+} \longrightarrow Fe^{3+} + Cu2^{+}$$

Reduction

- **Transferases:** These enzymes catalyse processes in which a functional group is transferred from a molecule known as the donor to a molecule known as the receiver or acceptor. For example, transaminases that transfer the amino group

$$AX+B \leftrightarrow BX+A$$

- **Hydrolases:** These enzymes are hydrolytic in nature as they catalyse the reaction in the presence of water. For example, pepsin hydrolyzed the peptide bond in the protein.

$$AX+H_2O \rightarrow XOH+AH$$

- **Lyases:** These enzymes catalyse the reaction, which involves the breaking of bonds without undergoing oxidation or hydrolysis. For example, aldolase converts the fructose-1,6-bisphosphate to glyceraldehyde-3-phosphate and dihydroxyacetone phosphate via catalysis.

$$AX+BY \rightarrow AB+XY$$

- **Isomerases:** It belongs to the enzyme family that changes the structural arrangement of the molecule, i.e., transforms the molecule from one isomer to another. For example, phosphoglucomutase catalyses the transformation of glucose-1-phosphate to glucose-6-phosphate during glycogenolysis.

- **Ligases:** A ligase is a catalytic enzyme that makes a new chemical link between two big molecules and helps them unite. The formation of a phosphodiester bond between two segments of DNA, for instance, is catalysed by DNA ligase.

$$A+B \rightarrow AB$$

Enzymes are selective in nature. Each enzyme catalysed a particular type of reactions. This specificity of enzyme can be towards the particular functional group, chemical bond, isomers, reaction, substrate etc. same substrate can take part in different reactions and each reaction are catalysed by specific enzymes. Urea is broken down by urease into ammonia and carbon dioxide is an example of absolute substrate specificity. The relative substrate specificity can be bond or group specific. The presence of an active site within the enzyme serves as the foundation for enzyme specificity. It is site where the enzyme binds with substrate and form enzyme substrate complex.

Emil Fischer's "lock-and-key" concept is one of the explanations offered for the specificity of the enzyme. The active site of the enzyme and the substrate are structurally complementary. The concept of absolute specificity shown by several enzymes is proven accurately by this theory. The significant drawback of lock-key theory is that the enzyme has a completely inflexible conformation. However, the structure of proteins is flexible and has the ability to undergo minute and fine changes in structural arrangement. This was wonderfully explained by Koshland in his induced-fit theory for enzyme catalysis. This idea states that the substrate is first attached to the enzyme, and then the active site undergoes structural modification to fit the substrate.

8.3. Factors Affecting the Rate of Enzyme Catalyzed Reactions

Various factors can affect how quickly enzyme-catalyzed reactions proceed. The most significant variables that can influence catalysis are the enzyme concentration, substrate amount, temperature, pH, electrolytes, and the presence of inhibitors. Enzyme kinetics is the study of the impact of various factors on the rate of catalysis.

8.3.1. Enzyme Concentration:

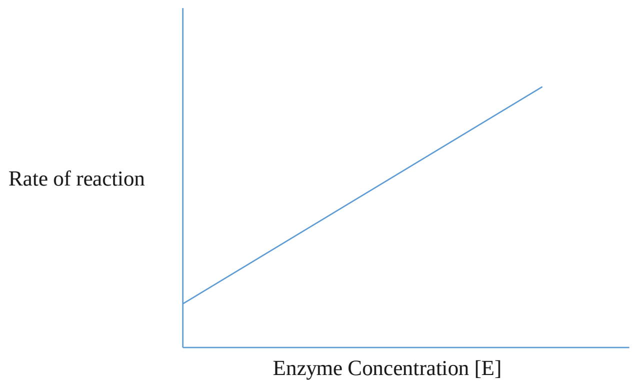

Figure 1: Effect of enzyme concentration on rate of reaction

A straight line is produced on the graph between enzyme concentration and rate of reaction, demonstrating that the rate of reaction is directly proportional to the enzyme concentration (see figure). The reaction rate increases with the concentration of the enzyme.

8.3.2. Substrate Concentration:

On a graph involving substrate concentration and reaction rate, a hyperbolic graph is produced. While the substrate concentration varies, the concentration of the enzyme remains constant (shown in figure). This indicates that, at low substrate concentrations, the reaction velocity increases (directly proportional to the substrate concentration) up to a certain level and then becomes independent of the substrate concentration. Even if the concentration of substrate rises, the reaction's speed is constant and sometimes remains the same.

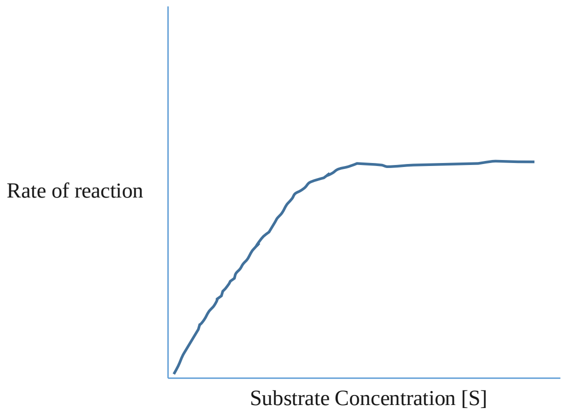

Figure 2: Effect of substrate concentration on rate of reaction

8.3.3. Temperature:

At low temperatures, the enzymes act very slowly. Like all chemical processes, the enzyme-catalysed reaction proceeds more quickly as the temperature rises. Each 10°C increase in temperature causes the reaction rate to double. Enzymes are proteins; therefore, as the temperature rises, the apoenzyme (the protein part of the enzyme) undergoes unfolding due to the cleavage of bonds (thermal denaturation), leading to the inactivation of the enzyme. A bell-shaped curve (shown in Fig.) is typically generated if the velocity of reaction against the temperature graph is plotted. The optimum temperature at which the enzyme activity is at its maximum depends on other factors like time, etc.

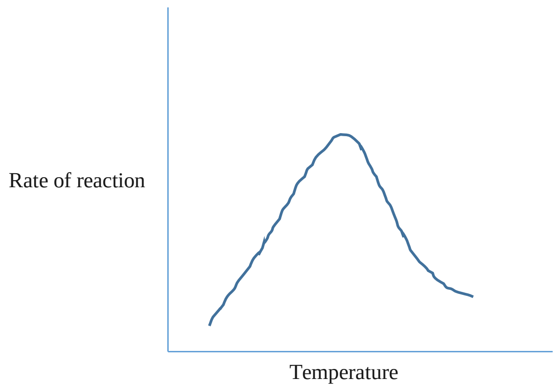

Figure 3: Effect of temperature on rate of reaction

Most of the enzymes are active at temperatures ranging from 30 °C to 40 °C. After this temperature, inactivation of the enzyme started, which is absolutely done at 50°C to 55 °C. Among all the enzymes, certain enzymes, like peroxidases, can resist higher temperatures.

In the food sector, enzyme thermostability is significantly important. It is preferable to avoid or regulate enzyme activity while preserving food because doing so would result in a food product with an off flavour, bad appearance, changed texture, or decreased nutritional composition.

These adverse effects can be avoided by heating meals for a short period of time to about 70°C. For instance, milk must be exposed to 63°C for about 30 minutes in order to be pasteurised. The inactivation of the enzymes by this process is sufficient to delay milk deterioration and hence increase its shelf life. Similar to this, when fruits and vegetables are blanched, all enzymes are inactivated by passing them to the boiling water, followed by cooling. As a result, enzymes including lipoxygenase, chlorophyllase, ascorbic acid oxidase, and phenolase are rendered inactive, avoiding the decay of fruits and vegetables during storage.

From the perspective of maintaining food quality, the impact of low temperatures on enzymes is important. In partially frozen conditions, many enzymes show notable activity. Enzyme activity can increase or decrease at temperatures between 0 and -10°C with respect to the enzyme and the system.

The enzyme activity is reduced as the temperature drops even lower. The medium's composition, the rate and degree of freezing, the impact of concentration on viscosity, and the intricate structure of the sample and freezing are going to affect the functioning of enzymes in a partially frozen state.

8.3.4. pH:

The pH of the reaction media affects an enzyme's ability to function. All enzymes are only functional within a small pH range, and each enzyme has an optimal pH where activity is at its peak. Between 4.5 and 8.0 pH, the majority of enzymes are active. In general, a bell shaped curve is formed when graph is plotted between the enzyme activity and pH (Fig.). The denaturation of the protein occurs with a concurrent loss of enzyme function at extremes of acidity and alkalinity.

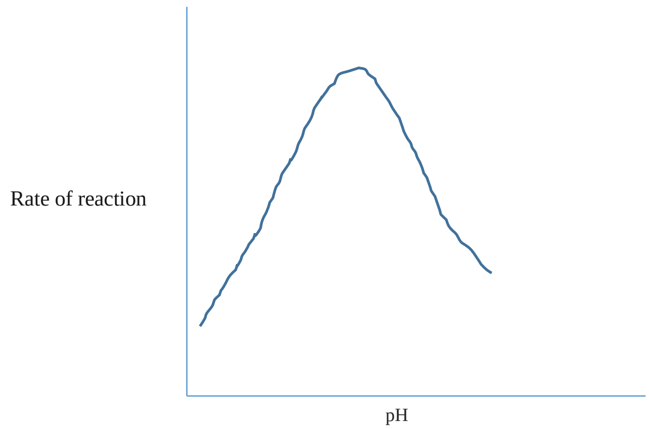

Figure 4: Effect of pH on rate of reaction

8.3.5. Other factors:

The activity of several enzymes depends on specific ions. An ion (cation and anion) may behave as an activator or an inhibitor, depending on the enzyme it interacts with. A particular ion may also block an enzyme or activate it.

8.4. Enzyme Inhibition

An inhibitor is a chemical that slows down the rate at which an enzyme-catalyzed process occurs. Enzyme inhibitors are useful in the domains of pharmacology, toxicology, Food Science etc. Inhibitors serve as essential component for comprehending the functioning of enzyme-catalyzed processes.

Irreversible and reversible inhibitions are the two categories of inhibition. The enzyme and inhibitor will join to create a stable enzyme inhibitor complex (EI) in the first scenario. When all of the enzymes and inhibitors have been combined, irreversible inhibition is complete. Reactivating the enzyme requires the eradication of the excess inhibitor. Additionally, nerve gases function as permanent inhibitors. It generally occurs when the enzyme is irreversibly denatured by extreme heat and pH. In the food industry, irreversible inhibition is very important.

Reversible inhibition occurs when an inhibitor interacts with an enzyme in a manner that can be reversed. Upon removing the inhibitor, the enzyme activity returns to normal. Based on their kinetic characteristics, reversible inhibitors can be classified as either competitive or non-competitive.

8.4.1. Competitive inhibition:

An inhibitor that fights with the substrate for the enzyme's active site. This indicates that the substrate's structure is comparable to that of the inhibitor. For instance, malonic acid competes with succinic acid for the active site of the enzyme succinic dehydrogenase, which transforms succinic acid into fumaric acid. This happens due to the resemblance between malonic acid and succinic acid, as both have two carboxyl groups that are equally spaced apart. The corresponding concentrations of the inhibitor and substrate determine the extent of inhibition. When there is a surplus of substrate concentration, competitive inhibition can be removed.

8.4.2. Non-competitive inhibition:

There are various methods in which non-competitive inhibitors interact with enzymes. By raising the substrate concentration, the inhibitory effect cannot be restored. V_{max} is significantly impacted by non-competitive inhibition.

8.5. Enzyme Inhibitors:

The application of enzyme inhibitors in food products is restricted due to issues with flavour, aroma, and toxicity. The most popular methods for inhibiting enzymes in food are heat, adjusting pH, using sulphur dioxide, and other substances like diethyl pyrocarbonate, which breaks down the substance without leaving any harmful residue. Tissues from plants and animals include a wide range of naturally occurring enzyme inhibitors. Mammalian and plant enzymes are both inhibited by plant enzyme inhibitors. All members of the leguminosae family of plants, including grains like wheat, rice, and corn, as well as the roots of potatoes and beets, contain plant-derived enzyme inhibitors. Thus, enzyme inhibitors are important in nutrition.

There has been substantial research on soy-derived inhibitors. Trypsin and chymotrypsin are affected by the about eight protease inhibitors found in soybean. Growth is slowed down when rodents are given unheated soybean meal. The deficiency of important amino acids that occurs naturally as a result of an overactive pancreas in response to the trypsin inhibitor may potentially be a contributing factor to the growth-inhibitory action of the trypsin inhibitor.

The soyabean trypsin inhibitor and the majority of plant protein inhibitors are eliminated by heat, increasing the protein's nutritional value. The actions of amylase, invertase, phosphorylase, and polygalacturonase are also inhibited by other inhibitors of particular enzymes found in plants. Various animal sources, like body secretions, beef pancreas, blood, and egg whites, have been found to contain enzyme inhibitors. Egg white contains ovomucoid and ovoinhibitors that behave as inhibitors. It blocks the functioning of trypsin and is not eradicated by cooking. Egg-white protease inhibitors have no impact on how much nitrogen is retained by humans; hence, they are of little nutritional significance.

8.6. Application of enzyme

In spite of the certain unfavourable alterations caused by enzymes, there are a number of activities that require their involvement to improve the quality of food products. Enzymes are used in a variety of processes, including baking, making confectionery items, tenderising meat, clarifying beverages such as fruit juices, developing flavours, etc. In the food industry, large quantities of commercial, partially purified enzymes are employed, which are acquired from plant, animal, and microbial sources. The application of enzymes in the production of food has a number of benefits. They are safe, organic substances that naturally catalyse a specific reaction without producing any undesirable side effects. They can be easily controlled and are active at mild temperatures, low concentrations, and pH conditions. They can also be deactivated when a specific reaction has reached the desired stage. Carbohydrase, proteases, lipases, and certain oxidising enzymes are some of the enzymes that are frequently utilised in the food industry.

8.7. Carbohydrases:

The enzymes employed by the food industry include carbohydrases such as α- and β-amylases, which cause the hydrolytic breakdown of amylase or starch; invertase (which breaks down sucrose into glucose and fructose); pectinases (which decompose pectic materials); cellulases, which act on cellulose; and sugar isomerase, which converts glucose to its isomer (fructose).

As already stated, there are two enzymes (α and β-amylases) involved in the baking process and in the production of glucose. In a random order, α-amylase breaks the α1, 4 bonds of amylase and amylopectin to release maltose. The α-1, 4 bonds in starch segments are likewise hydrolyzed by β-amylase, but it does so in a sequential manner, eliminating successive maltose units from the non-reducing end.

The α-1,6 linkages seen in amylopectin are not hydrolyzed by the α and β-amylases. These linkages can be broken by the amylo α-1, 6 glucosidase enzyme. The joint activity of both enzymes in flour is utilised in making bread. As a result of the enzyme activity, dextrins and maltose are produced, which provide the sugar for the fermentation process.

These enzymatic reactions persist during baking, but the functioning of the enzyme decreases as the temperature of the oven rises. The carbohydrases in the flour are going to decide the degree and type of alteration and are finally responsible for the softness, crust colour, volume, and texture of baked goods. For the formation of chocolate syrup (containing glucose), the complete breakdown of starchy paste is collectively brought about by enzymes such as α- and β-amylases, amylo-1, 6-glucosidase, and glucoamylase, which are obtained from microbial sources.

The necessary taste and thickness of sugar syrups can be achieved through the combined effects of acid and enzyme degradation. In the brewery sector, amylases convert starch into maltose, which is required for fermentation. In order to boost the dazzling qualities of jellies, they are also employed to remove starch turbidity.

Invertase is an enzyme that plays a crucial role in food science, with a variety of applications. It is commonly used in sweetener production, where it is used to break down sucrose into glucose and fructose, creating invert sugar. Invert sugar has several advantages over sucrose, including improved solubility, reduced crystallization, and enhanced flavor. It is also used in the production of certain beverages, such as beer and wine, to improve their flavour and aroma. It is commonly used in candy and confectionery production to improve texture, flavour, and shelf life, and in bakery and pastry production to improve the handling properties of dough. It can also have nutritional benefits, improving the digestibility and absorption of sucrose in the body. Overall, invertase is a versatile enzyme with numerous applications in food science, contributing to the production of high-quality, flavourful, and nutritious food products.

Pectic enzymes are a group of enzymes that are involved in the breakdown of pectin, a complex polysaccharide that is found in many plant cell walls. Pectin is an important component of fruit and vegetables, providing structural support and helping to maintain their shape and texture. Pectic enzymes are produced naturally by certain microorganisms and are also used in various industrial processes in the food and beverage industry. They are commonly used in fruit and vegetable processing to improve the extraction and clarification of juices, increase yield, and improve the texture and flavor of finished products. For example, pectic enzymes can be used to break down the cell walls of fruits and vegetables, making it easier to extract juice and pulp. This can result in higher yields of juice and a smoother, more homogeneous texture. Pectic enzymes can also be used to clarify fruit juices by breaking down the pectin and other insoluble materials, resulting in a clearer, more transparent juice.

Pectic enzymes are also used in the production of jams, jellies, and other fruit preserves. In this application, pectic enzymes are used to break down the pectin in fruit, resulting in a softer, smoother texture and improved spreadability. Pectic enzymes can also be used to improve the stability and viscosity of fruit syrups, sauces, and other products.

8.8. Oxidoreductases

In addition to hydrolytic enzymes discussed above, a number of oxidoreductases are of importance in food science. Some of the important ones are the following:

Glucose oxidase: This enzyme is required for the oxidation of glucose to gluconic acid. Generally, in this reaction, H_2O_2 is liberated, but catalase is found in the commercial formulation of glucose oxidase, which rapidly converts it into H_2O. It can be used in various carbonated beverages and wines to inhibit the browning reaction and hence, increased the shelf life of the product.

$$\text{Glucose} + O_2 \xrightarrow{\text{Glucose oxidase}} \text{Gluconic Acid} + H_2O_2$$

Peroxidases: as the name suggest the peroxidases act on peroxide (substrate). It has good thermal stability. This distinctive feature of the enzyme is utilised for determining the efficacy of blanching.

Ascorbic oxidase: Ascorbic oxidase (AO) is an enzyme that catalyzes the oxidation of ascorbic acid (vitamin C) to dehydroascorbic acid (DHA) in the presence of oxygen. AO is found in a wide range of plant and animal tissues, and is involved in several important biological processes. In food science, AO has both positive and negative effects on food quality. Here are some examples:

Browning of fruits and vegetables: AO plays a role in the browning of fruits and vegetables, which can lead to changes in color, flavor, and nutritional value. This can be both positive and negative, depending on the specific application. For example, in some fruits like apples and pears, browning can be considered a desirable characteristic, as it enhances the flavor and appearance of the fruit. In other fruits and vegetables, however, browning can indicate a loss of nutritional value and freshness.

Preservation of meat and fish: AO can also be used as a natural preservative in meat and fish products. By catalyzing the oxidation of vitamin C, AO can inhibit the growth of certain microorganisms that can spoil the food. This can help to extend the shelf life of the product and improve its safety.

Negative effects on nutrition: On the other hand, AO can also have negative effects on the nutritional quality of food. Vitamin C is an important antioxidant that can help to protect against oxidative stress and inflammation in the body. By oxidizing vitamin C, AO can reduce its antioxidant activity and potentially reduce the nutritional value of the food.

Influence on sensory characteristics: AO can also affect the sensory characteristics of food products, such as flavor and aroma. For example, in some fruits and vegetables, the oxidation of vitamin C can lead to the formation of off-flavors and odors.

Lipoxygenases:

Lipoxygenases (LOX) are a family of enzymes that catalyze the oxidation of polyunsaturated fatty acids (PUFAs) to form hydroperoxides, which can lead to the formation of various compounds such as aldehydes, ketones, and oxo-acids.

Proteins and vitamins in food are harmed by the intermediate products develops during the oxidation of fatty acid. This enzyme is naturally present in plant sources. Foods occasionally have an undesirable flavour and aroma that is caused by the activity of lipoxygenases. LOX enzymes have several applications in food science, including:

Flavor development: LOX enzymes are involved in the formation of aroma compounds in various foods, such as fruits, vegetables, and meats. These aroma compounds contribute to the characteristic flavors of these foods.

Color development: LOX enzymes can also contribute to the development of colors in certain foods. For example, LOX activity in apples can lead to the formation of brown pigments, which can affect the appearance of the fruit.

Texture modification: LOX enzymes can modify the texture of foods by altering the physical properties of lipids. For example, LOX activity in bread dough can lead to changes in the rheological properties of the dough, which can affect the texture of the final bread product.

Food preservation: LOX enzymes can be used as natural preservatives in certain foods. For example, LOX enzymes in milk can inhibit the growth of certain microorganisms, which can help to extend the shelf life of the milk.

Nutritional value: LOX enzymes are involved in the synthesis of bioactive lipids, such as leukotrienes and lipoxins, which have important roles in inflammation and immune function. These compounds can also have a beneficial effect on human health, such as reducing the risk of cardiovascular disease.

Overall, LOX enzymes have a variety of applications in food science, from flavor and color development to texture modification and food preservation. Understanding the role of LOX enzymes in food systems can help to improve the quality and nutritional value of food products

8.9. Proteases

Proteases enzymes break down the peptide links of a protein molecule. They have significant applications in various food sectors. Starch and protein are the major components of wheat flour. It should undergo some slight modification by the action of enzymes, which is needed for the desired texture, flavour, and shelf life of the final product. These proteases are obtained from the fungal sources. Meat is tenderised using a variety of proteolytic enzymes derived from different sources (plant, animal, and microbial). Meat tenderness is increased by using the enzymes such as bromelin, papain, Trypsin, ficin.

In the dairy industry, proteases are used during cheese production to coagulate milk proteins, which can result in the formation of a solid curd. This curd can then be processed further to make cheese. Proteases can also be used to modify the texture of yogurt and other dairy products by breaking down milk proteins into smaller peptides. In the baking industry, proteases can be used to modify the texture of dough and improve the volume of bread. By breaking down gluten proteins in flour, proteases can help to improve dough handling and make it easier to work with. This can result in a lighter and more airy bread. In the brewing industry, proteases can be used to break down proteins in beer production, which can help to improve beer clarity and stability. Proteases can also be used to modify the flavor of food products by releasing amino acids and peptides from proteins, which can enhance the umami flavor in food. Overall, proteases are important enzymes in the food industry due to their ability to modify proteins, which can have a significant impact on the texture, taste, and nutritional value of food products

8.10. Lipases:

Enzymes called lipases break down glyceride ester bonds. Triglyceride hydrolysis can result in the production of fatty acids, which can give meals a distinctive off-flavour. Additionally, lipases are used in the production of cheese. The significant breakdown of butter fat that occurs during cheese ripening produces a variety of fatty acids that give cheese its distinctive flavour. Lipases are employed to provide milk with a little cured flavour in milk chocolate.

8.11. Immobilized Enzymes

All of the fundamental biochemical reactions that take place inside an organism's body are biocatalyzed by enzymes. Their distinctive quality is that they don't change after the reaction is finished. They can therefore be utilised repeatedly. But the major drawback of soluble enzymes' is that they cannot be isolated from the product-substrate complex.

Therefore, the concept of immobilised enzymes have gained popularity in recent years as a useful tool for food preparation in the processing industry. Enzymes that have been introduced are often inactivated once they have completed their intended task. Furthermore, an enzyme sample must be used for each analysis in analytical applications. The automation of analytical procedures is possible because of immobilised enzymes, which can be employed repeatedly or constantly.

In other words we can say that Enzyme immobilization refers to the process of attaching an enzyme to a solid support or matrix, such as a bead, membrane, or gel, to create an enzyme-bound system that can be used in various biotechnological applications. Immobilization can increase the stability, activity, and reusability of enzymes, as well as facilitate their separation and recovery from reaction mixtures.

8.11.1. Types of enzyme immobilization technique:

8.11.1.1. Irreversible:

The immobilised enzyme has the ability to confine its movement in order to be physically recovered from the reaction medium. The immobilisation of the enzymes involves their chemical or physical attachment to some form of insoluble support or matrix. When using chemical immobilisation techniques, an enzyme residue and the insoluble support form a covalent bond. The original enzyme cannot be restored in such a situation.

Adsorption: It is the simplest and quickest technique for immobilisation. The extent of adsorption is influenced by different parameters such as the amount of enzyme and adsorbent, time, temperature, etc., and marks the major drawback. The relatively weak binding interactions between proteins and adsorbents necessitate tight control of these variables.

These weak interactions may be hydrogen bonding, van der Waals forces, or hydrophobic interactions. Under favourable conditions (at optimum pH and ionic strength), enzymes can be immobilised by simply combining them with the matrix. The enzymes are attached with extremely weak forces that, when present in sufficient amounts, provide enough binding strength to form the basis for the adsorption process.

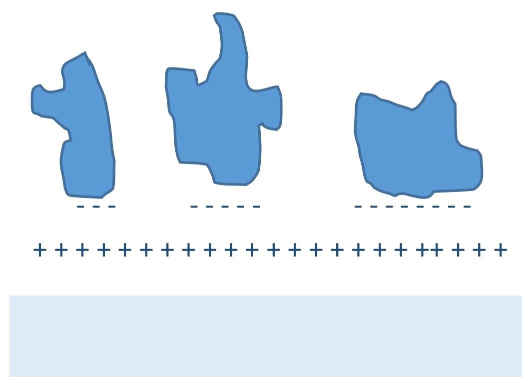

Figure 5: Adsorption

8.11.1.2. Reversible:

The physical immobilisation of enzymes can be accomplished through adsorption on insoluble matrices, trapping in gels or microcapsules, or confinement in semipermeable membranes. The physical immobilisation of enzymes can be reversed at any time. This technique includes covalent coupling crosslinking, entrapment and encapsulation.

The principle behind entrapment and encapsulation is the confinement of an enzyme within a structure that is just sufficient to enable the enzyme to release while still enabling a substrate to pass through. However, due to diffusion restrictions, these techniques are frequently ineffective for immobilising enzymes that hydrolyze macromolecules.

Entrapment involves the entrapment of enzymes within a porous support material, such as a gel or membrane, which allows for diffusion of substrates and products. Encapsulation involves the immobilization of enzymes within a protective shell, which provides a barrier against denaturation and proteolysis.

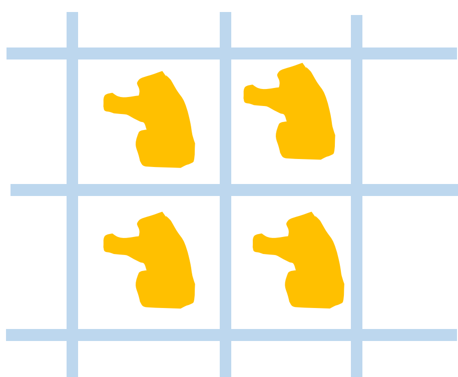

Figure 6a: Entrapment

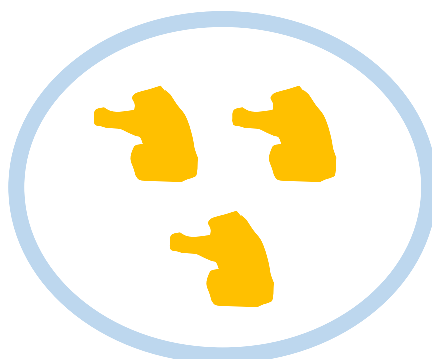

Figure 6b: Encapsulation

Support materials are a key element of an immobilised enzyme. The support material should have a greater surface exposed for binding with enzymes, be impermeable to substrate, be chemically, mechanically, and thermally stable, and be resistant to microbial contamination.

Enzyme immobilization is widely used in various fields such as biocatalysts production for industrial processes, biosensors for diagnostic purposes, and bioreactors for environmental remediation. For example, in the food industry, immobilized enzymes can be used to produce specific products such as glucose syrup from cornstarch. In medical applications, immobilized enzymes can be used to create biosensors that detect glucose levels in blood samples. Overall, enzyme immobilization is an important process that can provide a number of benefits in various fields, such as increasing the stability and activity of enzymes, reducing enzyme loss, and increasing enzyme reusability.

8.12. let us sum up

Enzymes are biological molecules that act as catalysts, increasing the rate of chemical reactions in living organisms. They are highly specific and can recognize and bind to specific substrates, facilitating their conversion into products. They are generally stable under specific conditions, such as their optimal temperature and pH range. However, they can become denatured or lose their activity when exposed to extreme conditions such as high temperatures, pH outside of their optimal range, or exposure to certain chemicals.

The action of enzymes involves a specific mechanism called the lock-and-key model. The enzyme's active site, which is the region where the substrate binds, has a specific shape and size that complements the substrate's shape and size. When the substrate binds to the active site, the enzyme undergoes a conformational change that facilitates the reaction, converting the substrate into a product. The product is then released, and the enzyme can catalyze another reaction. It plays an essential roles in various biological processes, including digestion, metabolism, and cellular signaling. They are also widely used in industrial processes, such as food production, bioremediation, and pharmaceuticals.

Enzymes are used in food science for various purposes, such as improving bread texture, coagulating milk for cheese production, extracting fruit juice, brewing beer, tenderizing meat, and modifying flavor compounds in dairy products.

Enzyme immobilization is a process of attaching enzymes to a solid support or matrix, which can be used in various applications. This process can help to increase enzyme stability, activity, and reusability. The process of immobilising an enzyme can be done in a number of ways, including physical adsorption, covalent binding, entrapment, and encapsulation. While covalent binding requires the establishment of a strong and stable link between the enzyme and support material, physical adsorption includes weak contacts between the enzyme and support material. Encapsulation includes immobilising enzymes inside a protective shell, whereas entrapment involves trapping enzymes inside a porous support material. Enzyme immobilization has many applications in biotechnology, including the production of biocatalysts for industrial processes, biosensors for diagnostic purposes, and bioreactors for environmental remediation.

8.13. Glossary

Enzymes: Specialized proteins that catalyze biochemical reactions, playing a vital role in many biological processes

Enzyme inhibitors: Molecules that can bind to enzymes and reduce or prevent their activity, often used in pharmaceuticals to target specific enzymes involved in disease processes

Competitive inhibition: the inhibitor molecule binds to the active site of the enzyme, competing with the substrate for binding.

Non-competitive inhibition: the inhibitor molecule binds to a site on the enzyme other than the active site, causing a conformational change that reduces enzyme activity.

Blanching: It is a food preparation technique that involves briefly boiling vegetables in water before plunging them into ice water to halt the cooking process.

Immobilized enzymes: The enzymes that are attached or confined to a support material, such as beads or membranes, allowing for their repeated use in industrial processes.

Enzyme entrapment It is a method of immobilizing enzymes by enclosing them within a gel or polymer matrix to protect them from harsh conditions while allowing substrate diffusion.

Encapsulation: It is a process of entrapping a substance, such as an enzyme or drug, within a protective shell or coating, allowing for controlled release and protection from degradation

Biosensor: It is a device that uses biological molecules, such as enzymes or antibodies, to detect the presence of a specific chemical or biological substance, often used in medical diagnosis, environmental monitoring, and food safety testing.

8.14. CHECK YOUR PROGRESS EXERCISE

Fill in the blanks:

1. The word "enzyme" was first coined by ……………….. in 1876.
2. ……………… is the first enzyme to be discovered.
3. Proteins having catalytic capabilities (speeding up the reaction) are referred to as ………………
4. The non-protein molecules that help some enzymes in their catalytic functions are known as ………………………
5. The organic cofactors are called……………….
6. The ………………………. refers to the entire active enzyme that includes both the protein and the cofactor.
7. The protein portion of holoenzyme is …………………

8. The substance at which enzymes act is ……………………..
9. The different forms of enzymes of a particular species are called ………………………….
10. All enzymes are protein in nature except……………………..
11. An inhibitor that fights with the substrate for the enzyme's active site is ……………………………...
12. Egg white contains …………………and ……………………….that behave as inhibitors.
13. Glucose oxidase is used along with ………………………… in various carbonated beverages and wines
14. ………………………………..enzyme is utilised for determining the efficacy of blanching.
15. …………………………... gets easily oxidized in the presence of ascorbic oxidase.
16. Lipoxygenase act on ………………………………………. and develops an undesirable flavour.
17. Proteases enzymes break down the ………………….links of a protein molecule.
18. Meat …………………………..is increased by using the enzymes such as bromelin, papain, Trypsin, ficin.

Short answer type question

1. Explain the factors affecting the rate of enzyme catalyzed reactions.
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2. Define enzyme. Discuss the classification of the enzymes in detail.
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3. State the difference between the competitive and non-competitive inhibitor.

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4. Discuss importance of oxidoreductases in food science.

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5. Mention the role of enzyme in food in food production.

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6. Elaborate the different techniques use for immobilization of enzyme in detail.

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7. Define the following terms:
   a) Adsorption

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b) Encapsulation

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8.15. Answer key

Exercise 1

1. W.F. Kuhne
2. Diastase
3. Enzyme
4. Cofactors
5. Coenzymes
6. Holoenzyme
7. Apoenzyme
8. Substrate
9. Isoenzymes
10. Ribozymes
11. Competitive enzyme
12. Ovomucoid, ovoinhibitors
13. Catalase
14. Peroxidase
15. Ascorbic acid
16. Essential fatty acid

17. Peptide
18. Tenderness

UNIT 9: MILK AND MILK PRODUCTS: COMPOSITION, PHYSICAL AND FUNCTIONAL PROPERTIES, DENATURATION AND EFFECTS OF PROCESSING AND STORAGE

7.1. Introduction: Milk and milk products
7.2. Composition
 7.2.1. Milk fat
 7.2.2. Milk proteins
 7.2.3. Milk sugar
 7.2.4. Salts
 7.2.5. Enzymes
 7.2.6. Colour
 7.2.7. Flavour and aroma
7.3. Physical properties
 7.3.1. Acidity
 7.3.2. Viscosity
 7.3.3. Freezing point
 7.3.4. Boiling point
7.4. Functional properties
 7.4.1. Emulsification:
 7.4.2. Foaming
 7.4.3. Gelling
 7.4.4. Texturizing
7.5. Denaturation
7.6. Processing and storage
 7.6.1. Clarification
 7.6.2. Pasteurisation
 7.6.3. Homogenisation
 7.6.4. Cooling and storage
 7.6.5. Further processing
 7.6.6. Packaging
7.7. Milk products
 7.7.1. Non-fermented products
 7.7.2. Fermented milk products
7.8. Let us sum up
7.9. Glossary
7.10. Check your progress

7.11. Answer key

9.1. Introduction: Milk and milk products

In this unit, we will focus on milk and milk products, specifically on their composition, physical and functional properties, denaturation, processing, and storage. Milk is a complex mixture of proteins, carbohydrates, lipids, minerals, and vitamins, each contributing to its unique properties. There is no substitute of milk as it contain almost all the nutrients. After the birth of their young, all mammals produce milk. Of all these animals, the cow, Buffalo and goat milk is used by man.

The physical properties of milk include its viscosity, surface tension, and ability to form foam, emulsions, and gels. Denaturation of milk proteins can occur due to various factors such as heat, pH, and mechanical agitation, resulting in changes in the milk's properties. Milk processing involves various methods such as pasteurization, homogenization, and sterilization, which can affect the properties of milk and milk products. We will discussed all these process in detail in this chapter. Proper storage of milk is essential to maintain its quality and prevent spoilage.

Overall, understanding the properties and processing of milk and milk products is essential for producing high-quality dairy products.

Objectives

You will be able to:

- Learn the composition of milk.
- Comprehend the various physical and functional property of milk.
- Learn about the Denaturation.
- Understand the effect of processing and storage on milk
- Learn about various milk and milk products.

9.2. Composition

It is a complex mixture of carbohydrates, proteins and lipids, as well as many other inorganic salts and organic compounds dissolved or dispersed in water. Fat is the milk constituent that varies most widely, followed by protein. The milk composition depends upon the species, breed, nutrition, lactational duration, and time between milkings. In addition to this, there is individual variation too.

9.2.1. Milk fat

Fat makes up about 6.5% of buffalo milk and 4.1% of cow's milk. Butterfat, or milkfat, is an excellent source of nutrients and is cost-effective. It is milk fat that is responsible for the milk's flavour. It is a good example of an oil-in-water emulsion. Under a microscope, these globules can be clearly seen. A lipid-protein complex and a trace quantity of carbohydrate make up the thin layer that surrounds each globule of lipid. Triglycerides as well as phospholipids are part of the lipid component. The size of fat globules ranges from 2 to 10 micrometres and is about 3 to 10 per millilitre in number. Due to the milk's low specific gravity, the larger fat granules rise to the surface more quickly, which may be seen during milk transportation.

The fat included in milk is a combination of various different glycerides. They have a 64% fatty acid content, with carbon atoms ranging from 4 to 26. Short chain fatty acids have a significant role in giving milk its distinctive flavour and off flavour.

They provide butter with a soft, firm consistency due to their low melting point (-10 to 12°C). Butyric and caproic acids make up 62% of saturated fatty acids, while unsaturated fatty acids make up 37%. Poly-unsaturated fatty acids make up 3.8% of the unsaturated fatty acids. Besides phospholipids, sterols, free fatty acids, carotenoids, and fat-soluble vitamins, milk also contains other lipid components. The yellow hue of milk fat is due to the presence of carotenoids. Volatile odours are extremely easily absorbed by milk fat. Therefore, the exposure of milk, butter, and cream to strong odours should be avoided.

9.2.2. Milk proteins

- **Casein:** It comprises about 30 percent of the total nitrogen present in milk. It develops when milk is acidified to a pH of 4.6 at 20°C. Lactoglobulin and lactalbumin make up the remaining whey protein. Milk's proteins consist of proteases, peptones, and milk enzymes. Caesin, which consists of phosphoric acid present in its molecular structure, is grouped as a phosphoprotein. The phosphoric acid portion of casein's structure combines with calcium caseinate, approximately at pH 6.6 in fresh milk. As a result, milk exhibits complex colloidal proteins of calcium phosphate.

  It is also called a glycoprotein. Casein primarily contains glutamic acid and also consists of proline, aspartic acid, leucine, lysine, and valine. It contains a good amount of essential amino acids. Casein comprises 8.2% calcium and 5.7% carbohydrates. The addition of rennin can separate casein from milk.

- **Whey proteins:** Whey proteins consist of a-lactabumin and ß-lactoglobulin, serum albumin, immunoglobulins, enzymes, and proteose-peptones. 50 percent of the total whey proteins are made up of ß-lactoglobulin. Heat can cause it to coagulate, but acid or rennin cannot precipitate it. Lactoferrin and serum transferrin are also present in minute amounts. The whey protein concentrate is formed by the ultrafiltration process. It is also possible to obtain whey protein isolates, which can be given to people with lactose intolerance.

9.2.3. Milk sugar

Carbohydrates range from 4–5% in milk. Although trace amounts of glucose, galactose, and other sugars are also present, the main carbohydrate present in milk is lactose. Glucose and galactose are produced when lactose is hydrolyzed. Lactose is about one-sixth as sweet as sucrose and has only one-fourth of its solubility in water. Milk turns brown when heated because of a reaction between lactose and protein. This is an example of nonenzymatic browning, which is also known as the Maillard reaction (already discussed in the previous unit). Butter, cheese, and curd are all produced through acid fermentation.

9.2.4. Salts

Milk contains sodium, potassium, calcium, and magnesium bicarbonates, as well as chlorides, phosphates, citrates, sulphates, and citrates. The condition and stability of the proteins are affected by these salts, particularly the casein fragment. The development of off-odours in milk and milk products depends on the presence of copper and iron. Milk also contains trace amounts of iodine, zinc, aluminium, molybdenum, and other metals.

9.2.5. Enzymes

The milk contains certain enzymes that come from mammary glands or may be transmitted by contaminated bacteria. Alkaline phosphatase is a lipoprotein that is found in both the lipid and aqueous phases. The effectiveness of pasteurisation is evaluated by testing the activity of the alkaline phosphatase enzyme, which is inactivated by pasteurisation techniques. In milk, there are many lipase species. These lipases account for the formation of a rancid taste in milk. Bacterial lipase has high thermal stability and is capable of producing significant quality problems. The lipases play a vital role in the formation of the desired flavour of cheese.

The membrane of the fat globule contains xanthin oxidase. It is a conjugated protein that has been combined with molybdenum, iron, and FAD. The enzyme breaks down FAD to produce FMN and riboflavin. Therefore, xanthin oxidase responsible for the milk's riboflavin content. Aldehydes can be oxidised by Xanthine Oxidase and give distinct aroma to the fermented dairy products. Pasteurisation does not render the enzyme inactive.

9.2.6. Colour

The colloidally distributed calcium, phosphorus, and casein give milk its white colour by reflecting light. Due to the presence of riboflavin and carotene, milk has a yellowish colour. Carotenes are fat-soluble and present in milk fat, whereas riboflavin (water-soluble) can be clearly seen in whey water.

9.2.7. Flavour and aroma

The sweetness in milk is due to the presence of lactose. Fat, protein, and certain salts, such as calcium phosphate, give flavour to the milk. Acetone, acetaldehyde, dimethyl sulphide, and short-chain fatty acids are low-molecular weight compounds that are responsible for the mild aroma of fresh milk. Certain volatile ingredients that contribute to milk's flavour are specific to the milk's fat content. The flavour of fresh milk is more altered by boiling than pasteurisation.

The oxidation of milk's phospholipids can lead to an oxidised flavour. Dairies should avoid using copper-containing equipment, as copper traces enhance the oxidised aroma. Certain poly-unsaturated fatty acids undergo auto-oxidation in the presence of oxygen, resulting in an undesirable flavour. A milk's off-flavour may also be affected by the cow's health or nourishment, bacterial action, or chemical changes in the milk. Milk exposed to light will also develop off-flavours. When the off-flavour develops, tryptophan and riboflavin may be involved in this reaction, and their content drops. It will be easier for the lipases to interact with the fat and cause rancidity.

9.3. Physical properties

Physically, milk is a dilute emulsion, colloidal dispersion and true solution.

9.3.1. Acidity: At 25°C, fresh milk has a pH ranging from 6.5 to 6.7. The loss of carbon dioxide causes milk to become somewhat less acidic when it is left in the open. Raw milk, which often has some lactic acid-producing bacteria, eventually becomes more acidic after being stored. Lactic acid bacteria are destroyed during pasteurisation.

9.3.2. Viscosity: Age, temperature, protein, and fat concentration, as well as milk's condition and concentration, are the parameters that can affect milk's viscosity. Acidity, salt balance, heat treatment, and the activity of numerous enzymes and bacteria are just a few of the conditions and processes that have an impact on casein stability. They can also affect the viscosity of milk. The amount of fat, the size of the fat globules, and the degree of globule clustering all influence viscosity. Viscosity is increased through homogenization and ageing.

9.3.3. Freezing point: Milk has a freezing point of -0.55°C. The soluble components, lactose and ash, are constant but influence the freezing point. Due to this fact, it is possible to find out whether milk is diluted or not. When 1% water is added to milk, the freezing point is lowered by -0.0055°C.

9.3.4. Boiling point: At the temperature at which milk boils (100.2°C), all organisms are wiped off. Boiling milk reduces the nutritional content; however, the avoidance of milkborne illnesses is more important.

9.4. Functional properties

Milk is a complex fluid that contains a variety of components with different functional properties. Some of the most important functional properties of milk are emulsification, foaming, gelling, and texturizing.

9.4.1. Emulsification: Milk has the ability to emulsify fats and oils, creating stable mixtures known as emulsions. The primary emulsifying agents in milk are proteins, particularly casein proteins. These proteins have the ability to form micelles, which are tiny aggregates of protein molecules that can surround and stabilize fat droplets in an aqueous environment. This emulsifying property of milk is important in the production of many food products, such as cream, butter, ice cream, and dressings.

9.4.2. Foaming: Milk also has the ability to create stable foams, which are important in many food products, such as meringues, soufflés, and whipped cream. The foaming ability of milk is due to the presence of whey proteins, which have the ability to denature and re-form in the presence of air, creating a stable network of protein molecules that can trap air bubbles.

9.4.3. Gelling: Milk proteins can also form gels, which are important in the production of many dairy products, such as yogurt, cheese, and pudding. The ability of milk proteins to form gels is due to their ability to interact with each other and form a network of protein molecules that can trap water and other ingredients. The primary gelling agents in milk are casein proteins, which can form a gel when they are acidified or subjected to heat.

9.4.4. Texturizing: Milk proteins can also be used to provide texture to food products. For example, milk proteins can be added to baked goods to improve their texture and provide a soft, chewy texture. Milk proteins can also be used to improve the texture of meat products, such as sausages and burgers, by acting as a binder and helping to hold the meat together.

In addition to the functional properties of its proteins, milk also contains fats, sugars, vitamins, and minerals, which contribute to the flavor, texture, and nutritional value of dairy products. For example, the fat in milk contributes to the flavor, texture, and mouthfeel of butter, cream, and cheese. The sugars in milk, such as lactose, contribute to the sweetness of dairy products and can also be used as a food source for bacteria in the production of fermented dairy products, such as yogurt and kefir. The vitamins and minerals in milk, such as calcium, phosphorus, and vitamin D, are important for bone health and overall nutrition.

9.5. Denaturation

Denaturation of milk refers to the process by which the protein molecules in milk are disrupted and lose their native structure, resulting in changes to the physical properties of milk. This can be caused by various factors such as heating, mechanical agitation, or changes in pH. Heating is one of the most common methods of denaturing milk proteins. When milk is heated, the protein molecules begin to unfold and lose their native shape. This can cause changes to the viscosity, texture, and color of the milk, and can also affect the ability of the proteins to function in other dairy products such as cheese and yogurt. Mechanical agitation, such as homogenization, can also cause denaturation of milk proteins. Homogenization is a process in which milk is forced through a small nozzle at high pressure, causing the fat globules to break down into smaller particles and become dispersed evenly throughout the milk. This process can also cause denaturation of the protein molecules, which can affect the texture and mouthfeel of the milk. Changes in pH can also cause denaturation of milk proteins. For example, when milk is acidified to make yogurt, the decrease in pH causes the protein molecules to denature and coagulate, forming a thick, creamy product.

9.6. Processing and storage

Milk processing is a complex and important process that plays a critical role in ensuring that dairy products are safe, nutritious, and appealing to consumers. It is a series of operations that are performed to transform raw milk into a range of dairy products, such as cheese, butter, yogurt, and milk powder. The process starts with the collection and transportation of raw milk from the farm to the processing plant. The milk is carefully monitored during transport to ensure that it is not subjected to any temperature fluctuations or contamination. The following are the typical steps involved in milk processing:

Collection and transportation: The milk is collected from the farm and transported to the processing plant. The milk is stored in insulated tanks to maintain its temperature and quality.

Reception and testing: The milk is tested for quality, including the levels of fat, protein, and bacteria. The milk is then weighed and recorded.

9.6.1. Clarification

Due to improper handling, milk can be contaminated with foreign particle, such as dust, dirt, and a variety of other substances. These foreign particle have to be remove by using a centrifugal clarifier. To avoid the cream separation from the milk, the speed of the clarifier can be regulated accordingly. This procedure removes all grime, dirt, mire, udder cells, and some bacteria. This process does not completely eliminate all harmful bacteria. After the clarification, pasteurization of milk can be done.

9.6.2. Pasteurisation

The French scientist Louis Pasteur, who discovered that heating some liquids to a high temperature increased their shelf life. Pasteurization term is given on his name. Basically, it involves heating milk to a temperature that kills almost all of the disease causing microorganisms contained in the product without significantly changing its basic structure or qualities**.** After the product has been pasteurised, it should be immediately cooled to a temperature low enough to prevent the growth of microorganisms that are tolerant to high temperature. Currently it is thought to be a necessary component in the production of butter, ice cream, and cheese industries. Some of the natural enzymes, such as lipase, are also rendered inactive by pasteurisation.

There are three methods of pasteurization namely Holding or Batch system, High Temperature Short Time Method (HTST) or the Continuous System and Ultra High Temperature System (UHTS)

- **Holding or Batch System:** Milk or cream is heated to a temperature of 65 °C, and this temperature is maintained for 30 minutes with successive cooling. If we increased the heating temperature then holding time can be reduced (For example, 69 C for 20 minutes). The temperature for heating and holding time are important to be managed properly in order to avoid any contamination. As some of the microorganism such as Coxielle burnetti, can withstand high temperature.
- **High Temperature Short Time Method (HTST) or the Continuous System:** The system is also known as a "continuous flow or flash pasteuriser" because the machines are built in a way that it can work continuously. The milk is heated to a temperature of at least 72°C for 15 seconds. After this quick cooling occurs. The cream line is unaffected, and the procedure does not give a cooked flavour to the milk.

- **Ultra-High Temperature System:** This technology is use to pasteurized milk completely. Milk is maintained 93.3°C for 3 seconds in this technique. The temperature can also be kept at 149.5°C for 1 second. Usually this technique is used in the dairy industry for the processing of milk or cream. Milk and milk product Pasteurised with this technique have longer keeping quality than any other process. Cooling (7°C) must be done after heating at high temperature for preventing bacterial multiplication. Milk pasteurized with this method have more distinct cooked flavour.

Role of Phosphatase in Pasteurisation:

Alkaline phosphatase is a heat sensitive enzyme which is present in raw milk. Hence, it can act as indicator for the pasteurization. Because of the distinctive property alkaline phosphatase (heat sensitive), it is subjected to closely associated with temperature and duration during pasteurization. If alkaline phosphatase activity in pasteurised milk persist and exceeds a specific level, indicates insufficient processing of milk. This enzyme act on the phenol phosphoric acid compound and release phenol, which gives dark blue colour.

Effect of Pasteurisation

Nutritive Value: As such there is no major change in nutritional composition. There is a loss of heat sensitive vitamins such as vitamin B_1 (Thiamine) and Vitamin C (Ascorbic Acid) whereas minerals are not much precipitated. Moderate amount of whey protein are denatured.

Flavour: No off flavour is produce in pasteurized milk. Only a distinctive flavour is develop which is highly acceptable as we have already discussed in this unit. This technique does not eliminate the compounds responsible for the flavour chemicals found in milk.

Micro-organisms:

Pasteurized milk contain vegetative spore that has an ability to proliferate**.**

Products that have been pasteurised are not sterile. They still contain vegetative creatures and spores that can proliferate. Some of the Pathogenic microorganism such as *Salmonella typhi, Mycobacterium tuberculosis (also known as Koch's bacillus), Corynebacterium diphtheria*, and *Brucella* are killed, while non-pathogens persist in the milk even after completion of pasteurisation. About 1 % of microorganism survive during the pasteurization.

Enzymes:

Some parameters like temperature, SNF (Solid Non Fat), specific gravity, bacterial contamination and acidity were assessed after the pasteurization for quality assurance. The quality of milk is slightly affected by the deactivation of lipase enzyme. Under the room temperature, pasteurized milk get spoiled within a day. It can be stored at lower temperature for a week.

9.6.3. Homogenisation

Homogenization is the mechanical process of making homogenous mixtures. Through this technique, the emulsion of milk serum and milk fat is stabilised.

In this process, warm milk or cream is forced under intense pressure and speed through a small aperture. Generally, the diameter of fat globules ranges from 0.1 to 20 um in milk and cream. The density of fat globules in milk is lower than in skimmed milk; they tend to aggregate and rise. The diameter of a fat globule in homogenised milk is 2um.

Fat globules grow in number and surface area as their size decreases. Each fat globule is surrounded by a film of protein, or lipoprotein. This film acts as an emulsifier and inhibits them from rejoining. Thus, it inhibits the rise and provides stability to the emulsion. This process provides the smother texture and white appearance to different milk products prepared from homogenised milk. The curd obtained from homogenised milk is softer and easier to digest. Lipase activity increases during homogenization, resulting in rancidity. Therefore, it should be done prior to pasteurisation.

9.6.7. Cooling and storage: The milk is cooled and stored in refrigerated tanks to maintain its freshness and quality.

9.6.8. Further processing: The milk can then be further processed into a range of dairy products, such as cheese, butter, yogurt, and milk powder. The specific processing steps required will depend on the type of product being produced. For example, cheese production involves curdling the milk and separating the curds from the whey, whereas yogurt production involves fermenting the milk with specific bacteria.

9.6.9. Packaging: Once the final product has been produced, it is packaged and labeled for distribution to retail outlets and consumers. The packaging and labeling process is critical to ensure that the product is properly identified and that consumers are provided with all of the necessary information about the product, including its ingredients, nutritional content, and shelf life.

9.7. MILK PRODUCTS:

Milk products are a variety of dairy products that are made from milk, which is produced by the mammary glands of mammals. These products can be broadly classified into two categories: fermented and non-fermented dairy products.

9.7.1. NONFERMENTED PRODUCTS

Non-fermented milk products are dairy products that are not produced through the process of fermentation. These products include milk, cream, and butter, which are obtained from fresh milk through various processing methods. Milk is typically pasteurized, homogenized, and standardized before it is consumed or used in the production of other dairy products. Cream is separated from milk through centrifugation, while butter is made by churning cream until the fat separates from the buttermilk. Non-fermented milk products are rich in nutrients such as calcium, protein, and vitamins, and are used in a variety of culinary applications.

- **Whey protein concentrate:** The milk is first made to coagulate by adding acid or rennet. Whey is subjected to the ultrafiltration process, to obtain protein concentrate. The protein quantity ranges from 20 to 80 per cent. Whey contains concentrated and preserved biologically active ingredients, such as cysteine, which activates the glutathione system, a potent antioxidant.

  Whey protein concentrate is a popular ingredient in food preparation due to its high protein content and functional properties. It is a by-product of cheese production and is made by removing the water, lactose, and minerals from whey. Whey protein concentrate is commonly used in protein bars, baked goods, smoothies, and other food products to increase their protein content. It can also be used as a thickener, emulsifier, and stabilizer in certain recipes. When using whey protein concentrate in food preparation, it is important to consider its solubility, texture, and flavor. Whey protein concentrate is not as soluble as whey protein isolate, which means it may not dissolve as easily in liquids. It can also have a slightly gritty texture and a slightly sweet taste, which may affect the flavor of the final product. To avoid these issues, it is recommended to mix whey protein concentrate with other dry ingredients before adding them to wet ingredients. This can help improve its solubility and texture. It is also important to choose a high-quality whey protein concentrate that has been properly processed and does not contain any unwanted additives.
- **Skim Milk:** Skim milk is a type of milk that has had most or all of the fat removed. Skim milk contains less than 0.5% milk fat by weight, which makes it a low-fat dairy product that contains water, protein, carbohydrates (primarily lactose), and essential vitamins and minerals, including calcium, vitamin D, riboflavin, and vitamin B12. Skim milk is a good source of high-quality protein, which contains all of the essential amino acids that the body needs. It is a nutrient-rich beverage that is a popular choice for those who are looking to reduce their calorie and fat intake while still getting the benefits of dairy

Skim milk is produced by removing the cream from whole milk through a process called centrifugation, which separates the fat from the milk. The remaining liquid is then homogenized to create a smooth and uniform texture. Skim milk can be consumed on its own, used as an ingredient in cooking and baking, or added to coffee or tea.

- **Evaporated milk:** Evaporated milk is a dairy product that is made by heating fresh milk until around 60% of its water content evaporates. The process of evaporating milk is done in a controlled manner to minimize damage to the milk proteins and other components. During the heating process, the milk is exposed to temperatures that denature the proteins in the milk, which means they lose their original structure and function. The denaturation of milk proteins can lead to the formation of a skin or film on the surface of the milk, which is undesirable in the final product. The heating and evaporation process also causes the lactose in the milk to undergo a Maillard reaction, which is a chemical reaction between amino acids and reducing sugars that results in the browning of the milk and the development of a slightly caramelized flavor. This flavor is a characteristic feature of evaporated milk and makes it distinct from fresh milk. Evaporated milk has a longer shelf life than fresh milk because most of the water content is removed, which helps to prevent spoilage. The concentrated milk product is canned and sterilized to further prevent microbial growth, which extends the shelf life of the product.

  It is often used as a substitute for cream in recipes, as it has a lower fat content than cream but still provides a rich, creamy texture. It can also be used as a substitute for regular milk in recipes that require a richer and creamier texture, such as custards, puddings, and sauces. Evaporated milk is a good source of protein, calcium, and vitamin D, and is often fortified with additional vitamins and minerals. It has a longer shelf life than fresh milk and can be stored at room temperature until it is opened. Once opened, it should be refrigerated and used within a few days.

- **Sweetened condensed milk**: Sweetened condensed milk is a thick and sweet dairy product that is made by removing most of the water content from milk and adding sugar to create a concentrated and viscous liquid. The process of making sweetened condensed milk involves heating fresh milk to remove water and then adding sugar to the concentrated milk. It contains a small amount of water, usually less than 10% by weight. The sugar content of sweetened condensed milk is typically around 45-55% by weight, which contributes to its thick and syrupy texture.it also helps to preserve the product by inhibiting microbial growth, and it also contributes to the sweet flavor and thick texture of the final product. However, in general, sweetened condensed milk typically contains around 28-30% milk solids. It has a relatively high fat content compared to other types of milk, usually around 8-10% by weight.

  The production of sweetened condensed milk requires careful control of temperature and time to prevent the milk from scorching or overheating, which can affect the texture and flavor of the final product. The concentrated milk-sugar mixture is typically heated under vacuum to reduce the boiling point of the liquid and prevent it from overheating or burning.Sweetened condensed milk is often used as a flavoring and sweetening agent in baked goods and desserts, such as cakes, pies, and ice cream. It is also a popular ingredient in recipes for fudge and candy because it has a high sugar content that helps to create a smooth and creamy texture. Sweetened condensed milk is a high-calorie product that is rich in sugar and fat. However, it is also a good source of protein, calcium, and vitamin D, and it can be a convenient and versatile ingredient in a wide range of recipes

- **Toned milk:** Toned milk is a dairy product that has been standardized to have a specific fat content. It is made by adding skim milk powder and water to whole milk to reduce its fat content. According to the PFA, toned milk must have a minimum fat content of 3% and a maximum fat content of 3.5%. The solid-not-fat (SNF) content of toned milk can vary, but it is typically around 8.5-9%. SNF refers to the total non-fat components in milk, including protein, lactose, vitamins, and minerals. The addition of skim milk powder also increases the protein content of toned milk. Toned milk is commonly consumed in countries like India, where it is sold as a more affordable alternative to whole milk.

- **Double Toned milk:** Double toned milk is a type of milk that is similar to toned milk, but has an even lower fat content. It is made by adding water and skim milk powder to whole milk to reduce the fat content to around 1.5-1.8%. This makes it a popular choice for people who are looking for a low-fat alternative to regular milk. The solid-not-fat (SNF) content of double toned milk can vary depending on the specific product, but it is typically around 9-10%. SNF refers to the total non-fat components in milk, including protein, lactose, vitamins, and minerals.

  Double toned milk has a higher SNF content than regular whole milk because the fat has been removed and the proportion of other milk solids like protein and lactose is higher. This makes double toned milk a nutritious and low-fat alternative to regular milk, and it is often used in households and by manufacturers to make dairy products like curd, paneer, and buttermilk
- **Filled milk:** The fat content of filled milk is typically lower than that of whole milk, ranging from 0.5-3% fat. The SNF content of filled milk is similar to that of whole milk, ranging from 8-9%.
- **Flavored milk**: The fat content of flavored milk is typically similar to that of whole milk, ranging from 3-3.5% fat. The SNF content of flavored milk is also similar to that of whole milk, ranging from 8-9%.
- **Cream:** The fat content of cream can vary depending on the type of cream, with heavy cream containing the highest fat content and light cream containing less fat. Heavy cream can range from 36-40% fat, while light cream may have 18-30% fat. The SNF content of cream includes protein and other milk solids, ranging from 6-8%.

9.7.2. Fermented milk products

Fermented milk products are dairy products that are made by adding beneficial bacteria cultures to milk, which convert lactose into lactic acid. This process causes the milk to thicken and form curds, resulting in various products such as curd (yogurt), cheese, and buttermilk. These products have a longer shelf life than fresh milk, and the beneficial bacteria they contain can provide health benefits such as aiding digestion and boosting the immune system. Some popular fermented milk products include Greek yogurt, kefir, sour cream, and cottage cheese.

- **Butter:** Butter is a dairy product made from milk or cream, typically cow's milk. The process of making butter involves separating the milk or cream into butterfat and buttermilk through churning or other methods. The resulting butterfat can be further processed to produce various types of butter, including salted or unsalted, cultured or uncultured, and clarified or regular. Butter is primarily composed of milkfat, which makes up about 80% of its total weight. The remaining 20% is made up of water and milk solids, including protein, lactose, and minerals. The composition of butter can vary depending on the type and brand, but most types of butter contain around 80-85% fat, 15-16% water, and 1-2% milk solids.
- **Cheese:** Cheese is a dairy product made by curdling milk with an acidic substance such as lemon juice, vinegar, or rennet, and then separating the solid curds from the liquid whey. The curds are then processed through various steps such as heating, cutting, salting, and aging, to create different types of cheese.

  Milk Collection: The milk used in cheese making is typically collected from dairy farms and transported to the cheese manufacturing facility in refrigerated tankers.

  Pasteurization: The milk is heated to a high temperature (around 72°C for 15 seconds) to kill any harmful bacteria and extend the shelf life of the cheese.

Coagulation: An enzyme or acid is added to the milk to curdle it and separate the solid curds from the liquid whey.

Curd Cutting and Cooking: The curds are cut into small pieces and heated to a specific temperature to remove additional moisture and develop the desired texture and flavor.

Salting: Salt is added to the curds to enhance the flavor and help preserve the cheese.

Shaping and Pressing: The curds are shaped into blocks or wheels and pressed to remove any remaining whey and create a firm texture.

Aging: The cheese is aged for a specific amount of time in temperature and humidity-controlled environments to develop the desired flavor, texture, and aroma

Cheese can be classified into different categories based on their texture, which is determined by the moisture content and aging process. Some common types of cheese classification based on texture include:

Soft Cheese: These cheeses have a high moisture content and are typically unaged or only aged for a short period. Examples include brie, camembert, and feta.

Semi-Soft Cheese: These cheeses have a moderate moisture content and are usually aged for a short to moderate period. Examples include havarti, gouda, and Monterey Jack.

Hard Cheese: These cheeses have a low moisture content and are usually aged for a longer period. Examples include cheddar, parmesan, and pecorino romano.

Bacterial ripening and mold ripening are two common methods used in the ripening process of cheese. Bacterial ripening involves the use of specific bacteria to ferment the cheese and produce certain flavors and textures. This process can be done using either surface-ripening or internal-ripening methods. Surface-ripening involves applying the bacteria to the surface of the cheese, allowing it to grow and develop over time. Examples of cheeses that undergo surface-ripening include brie, camembert, and some blue cheeses. Internal-ripening involves adding the bacteria directly to the cheese curd before pressing and aging, which results in a more uniform distribution of the bacteria throughout the cheese. Examples of cheeses that undergo internal-ripening include cheddar, gouda, and some swiss cheeses. Mold ripening involves the use of specific molds, such as Penicillium roqueforti, to develop the unique flavors and textures of the cheese. Mold-ripened cheeses are typically aged for a shorter period of time and have a distinctive blue-green marbling or white rind. Examples of cheeses that undergo mold-ripening include blue cheese, brie, camembert, and some goat cheeses. Mold-ripened cheeses are often referred to as "bloomy rind" or "blue-veined" cheese.

- **Curd:** Curd is a coagulated milk product that forms when milk is treated with an acid, such as lemon juice or vinegar, or with rennet, an enzyme that causes the milk proteins to coagulate and form curds. The process of manufacturing curd involves several steps:
    - Milk is heated to a specific temperature, usually around 85-90°C, to kill any harmful bacteria that may be present.
    - The milk is then cooled down to a specific temperature, usually around 40-45°C, which is the optimal temperature for the growth of the bacteria that will be used to ferment the milk.
    - A starter culture of bacteria is added to the milk, which will ferment the lactose (milk sugar) in the milk and produce lactic acid. This lowers the pH of the milk and causes the proteins to coagulate and form curds.
    - The milk is then left to ferment for a period of time, usually several hours, depending on the desired texture and flavor of the curd.
    - Once the curd has formed, it is typically cooled down to stop the fermentation process and to set the texture of the curd.
    - The curd is then typically strained to separate it from the liquid whey, which is drained off.

The quality and texture of the curd depend on various factors, including the type of milk used, the method of coagulation, and the processing techniques used to separate the curds and whey. Factors such as temperature, acidity, and stirring also play a role in determining the final texture and flavor of the curd. Curd is a popular ingredient in many cuisines around the world, and is used in dishes such as cheese and yogurt dips, sauces, and desserts.

- **Yogurt,** also known as curd, is a dairy product made by fermenting milk with a combination of Lactobacillus bulgaricus and Streptococcus thermophilus bacteria. The milk is heated to a temperature of around 80-85°C for 30 minutes to kill any harmful bacteria present in the milk. The milk is then cooled to a temperature of around 42-45°C, which is the ideal temperature for the bacterial culture to grow. A small amount of curd or a starter culture containing bacteria such as Lactobacillus bulgaricus and Streptococcus thermophilus is added to the milk. The bacteria convert lactose, the natural sugar in milk, into lactic acid, which causes the milk to thicken and form curds. The milk is left to ferment for 6-12 hours at a temperature of around 42-45°C. During this time, the bacteria continue to multiply and produce lactic acid, which lowers the pH of the milk and causes it to thicken and form curds. Once the curd has formed, it is strained to separate the liquid whey from the solid curds. The curd is then chilled to stop the fermentation process and to stabilize the texture. The final product is a thick, creamy curd that can be eaten plain or used as an ingredient in various dishes. The flavor and texture of the curd can be adjusted by varying the type of milk used, the temperature and duration of fermentation, and the bacterial culture used.

9.8. let us sum up

Milk is a complex emulsion consisting of water, fat, protein, lactose, minerals, and vitamins. The functional properties of milk are largely attributed to its protein content, which is comprised of two main types: casein and whey proteins. These proteins provide milk with its unique emulsifying, foaming, and gelling properties, which are important for the production of various dairy products.

The physical properties of milk can be affected by various factors such as temperature, pH, and mechanical treatment. For example, heating milk can cause denaturation of the proteins, leading to changes in its viscosity and texture. Similarly, mechanical treatment such as homogenization can alter the size and distribution of fat globules in milk, affecting its creaminess and mouthfeel.

The processing of milk and milk products can also affect their physical and functional properties. For example, the production of cheese involves coagulating milk proteins and separating the curd from the whey, resulting in a product with a different texture and composition than milk. Similarly, the production of yogurt involves fermenting milk with specific bacterial cultures, which can alter the texture and flavor of the product.

Storage and handling can also affect the physical and functional properties of milk and milk products. For example, exposure to light and air can cause oxidation of the fat in milk, leading to rancidity and off-flavors. Similarly, improper storage conditions can lead to spoilage and the growth of harmful bacteria. In summary, milk and milk products have complex compositions and physical properties that can be affected by various factors such as processing, storage, and handling. Understanding these properties is important for the production of high-quality dairy products.

9.9. CHECK YOUR PROGRESS EXERCISE

Fill in the blanks:

1. The size of fat globules ranges from ……………………micrometres.
2. …………………………… have a significant role in giving milk its distinctive flavour.
3. The yellow hue of milk fat is due to the presence of …………………

4. ………………… comprises about 30 percent of the total nitrogen present in milk.
5. Fifty percent of the total whey proteins are made up of …………………….
6. The membrane of the fat globule contains ……………………….
7. The foaming ability of milk is due to the presence of ……………………..
8. ……………………………is a heat sensitive enzyme and act as indicator of complete pasteurization
9. …………………………of milk refers to the process by which the protein molecules in milk are disrupted and lose their native structure, resulting in changes to the physical properties of milk
10. The emulsion of milk serum and milk fat is stabilised by the process of ………………………….
11. According to the PFA, toned milk must have a minimum fat content of …………………………..
12. The double toned milk contains ………………….. of solid-not-fat (SNF).
13. The cheese is ………………. to develop the desired flavor, texture, and aroma
14. ……………………….involves the use *of Penicillium roqueforti,* to develop the unique flavors and textures of the cheese.

Short answer type question

1. Briefly explain the composition of milk.

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   ………………………………………………………………………………
   …………………………………………………..……………………….
2. State the physical property of milk.

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3. Define the following terms:

   a) Emulsification

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   b) Gelling

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4. Briefly explain the different methods of pasteurization.

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5. State difference between the bacterial and mold ripening.

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6. Discuss the manufacturing process of curd

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7. Define the following terms:

   c) Clarification

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…………………………………………………………………
…………………………………………………

d) Homogenization

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…………………………………………………………………
…………………………………………………

9.10. Answer key

1. 2 to 10
2. Short chain fatty acids
3. Carotenoids
4. Casein
5. ß-lactoglobulin
6. xanthin oxidase
7. whey proteins
8. Alkaline phosphatase
9. Denaturation
10. Homogenization
11. 3%
12. 9-10%.
13. Aged
14. Mold ripening

BLOCK-4 MEAT, EGG AND POULTRY, SEA FOODS

The complex microscopic framework of meat, which includes its muscle fibres, myofibrils, connective tissue, adipose tissue, blood arteries, nerves, and water content. This structure affects the meat's texture, tenderness, flavour, and cooking behaviour. Optimising cooking methods and the quality of meat preparations requires an understanding of these tiny properties. In this block you will learn about nutritional value, composition, post-mortem alterations, processing, ageing, and preservation methods of meat's egg, poultry, fish and sea foods as well as their impacts.

Unit- 10 focuses on **'Meat, Egg and Poultry'**. The muscle composition, characteristics, structure, post mortem changes, processing and preservation are discussed in detail in this unit. We will discussed the structure and composition changes during storage and functional properties of eggs.

Unit-11 contains information related to '**Fish and Sea Food'**. The types and composition, fish storage and changes during storage are discussed in this section.

Unit-12 includes "**Pulses and legume**" in its scope of coverage. In this lesson, we will discuss the structure, composition and processing.

UNIT 10: MEAT, EGG AND POULTRY

10.1. Introduction

In this unit you are going to learn about the intricate microscopic structure of meat, with its muscle fibers, myofibrils, connective tissue, adipose tissue, blood vessels, nerves, and water content, collectively influences the meat's texture, tenderness, flavor, and cooking behavior. Understanding these microscopic characteristics is essential for proper cooking techniques and optimizing the quality of meat preparations. Meat and meat products are an essential part of the human diet and have been consumed for thousands of years. From a food science perspective, meat refers to the edible tissues of animals, primarily mammals that are consumed as food. You will also study about the composition, nutritional value of meat, post mortem changes, ageing, processing, preservation and their effects, heat induced changes in meat, tenderizers and meat products. A detailed discussion will be done on structure, Composition of egg, Changes during the storage, Functional properties of eggs used in cookery and Egg Cookery.

Objectives

After studying this unit, you will be able to:

- Learn about the microscopic structure of meat, its composition and nutritional value.
- Comprehend the post mortem changes and ageing.
- Understand the processing, preservation and their effect, heat induced changes in meat and tenderizers
- Learn the basic concept of Eggs structure, composition, changes during the storage and functional properties of eggs used in cookery

10.2. Structure

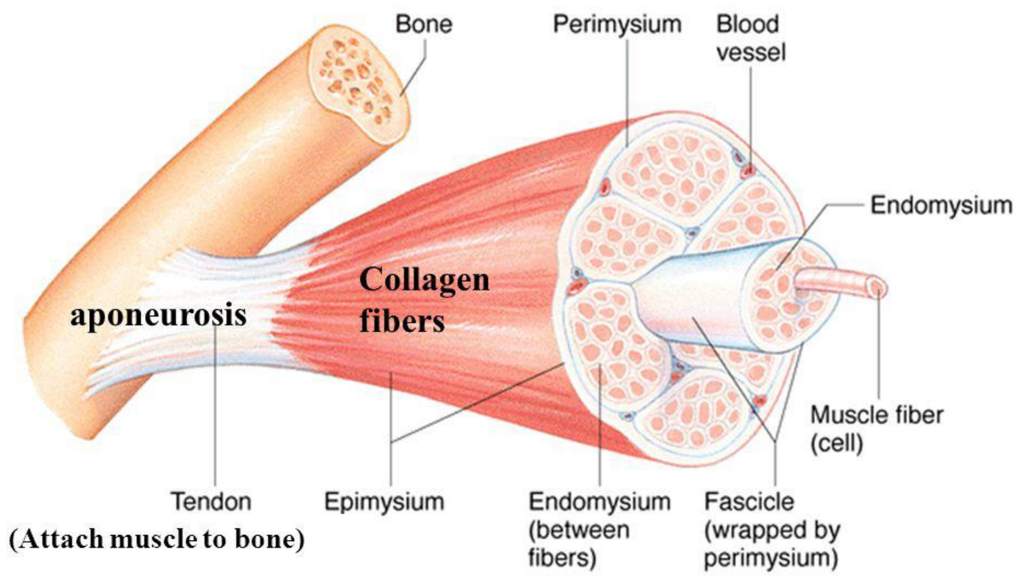
At a microscopic level, the structure of meat is highly complex and consists of various components. The main building block is the muscle fiber, which is a long, multinucleated cell responsible for muscle contraction. These muscle fibers are organized into bundles known as fascicles, which are held together by connective tissue. The connective tissue is primarily composed of collagen and elastin, providing structural support and resilience to the muscle. Collagen forms a network that surrounds and connects the muscle fibers, while elastin contributes to the meat's elasticity.

Within the muscle fibers, there are myofibrils, which are highly organized structures made up of repeating units called sarcomeres. Sarcomeres contain thick filaments composed of myosin proteins and thin filaments composed of actin proteins. During muscle contraction, the myosin heads interact with the actin filaments, forming cross-bridges and causing the filaments to slide past each other, resulting in muscle shortening and contraction.

The connective tissue in meat is crucial and consists of several layers. The endomysium surrounds individual muscle fibers, providing support and insulation. The perimysium surrounds bundles of muscle fibers, called fascicles, and contains blood vessels and nerves that supply the muscle fibers within the fascicle. The outermost layer, called the epimysium, encloses the entire muscle and provides structural integrity.

Adipose tissue, or fat, is present within the muscle tissue and between muscle fibers. It appears as small globules or clusters and contributes to the marbling or intramuscular fat content. The amount and distribution of fat affect the flavor, tenderness, and juiciness of meat.

Blood vessels, including arteries, veins, and capillaries, are distributed throughout the muscle tissue, ensuring the delivery of oxygen, nutrients, and hormones to the muscle fibers. Nerves, such as motor neurons, transmit signals for muscle contraction and coordination. Water is a critical component of meat, found both within the muscle fibers (intracellular) and in the spaces between the fibers (extracellular). It plays a vital role in maintaining the meat's moisture, tenderness, and juiciness.



Source: https://stefangourmet.com

Fig 1: Structure of muscle

10.3. Muscle composition

Meat is a complex food composed of various components, including water, protein, fat, vitamins, minerals, and trace elements. The specific composition of meat can vary depending on the type of meat and the cut of the meat. Here is a general breakdown of the composition of meat:

Proteins are complex macromolecules composed of amino acids linked together by peptide bonds. Meat proteins are considered complete proteins as they contain all the essential amino acids required by the human body. They are highly digestible and provide essential amino acids for muscle growth, repair, and maintenance. The protein content in meat is an important nutritional consideration for individuals with dietary protein requirements or those involved in physical activities requiring muscle protein synthesis. The protein composition of meat is diverse and consists of different types of proteins, including myofibrillar proteins, sarcoplasmic proteins, and connective tissue proteins.

Myofibrillar proteins: Myofibrillar proteins are the major proteins found in meat and are responsible for the muscle structure and contraction. These proteins include myosin, actin, tropomyosin, troponin, and nebulin. Myosin and actin are the predominant proteins, forming the basis of muscle fibers. They contribute to the meat's texture and contractile properties.

Sarcoplasmic proteins: Sarcoplasmic proteins are found in the sarcoplasm, the cytoplasm of muscle cells. These proteins include enzymes, globulins, myoglobin, and creatine kinase. Myoglobin, a sarcoplasmic protein, is responsible for the red color of meat and its ability to bind and store oxygen.

Connective tissue proteins: Connective tissue proteins are present in the extracellular matrix of meat and include collagen and elastin. Collagen is the most abundant protein in connective tissues, providing strength and structure to muscles, tendons, and ligaments. It contributes to the toughness and chewiness of meat.

Elastin is a fibrous protein composed of repeating amino acid sequences rich in glycine, valine, alanine, and proline. It forms a network within connective tissues, working in conjunction with collagen to provide strength and support. While collagen provides structure and resistance to tension, elastin allows tissues to stretch and then return to their original shape. In meat, elastin is mainly found in less tender cuts or parts of the animal that are subject to greater mechanical stress, such as tendons, ligaments, and some connective tissues. It is more resistant to breakdown during cooking compared to collagen, contributing to the toughness of certain cuts of meat.

While elastin is not as readily digestible as other proteins, its presence in meat provides important structural and functional properties. It is worth noting that elastin content can vary depending on factors such as the age and species of the animal, as well as the specific cut of meat.

Fat: Fat is another essential component of meat, contributing to its flavor, juiciness, and tenderness. The fat content in meat can vary widely, depending on the animal species, breed, diet, and cut of meat. For example, lean cuts of meat, like skinless chicken breast, have lower fat content, while marbled cuts of beef have higher fat content.

Vitamins: Meat contains several essential vitamins, including B vitamins (such as thiamin, riboflavin, niacin, vitamin B6, and vitamin B12), vitamin A, vitamin D, and vitamin E. The vitamin content can vary depending on the type of meat and the animal's diet.

Minerals: Meat is a good source of various minerals that are important for overall health. Some of the minerals found in meat include iron, zinc, selenium, phosphorus, magnesium, and potassium. The mineral content can vary depending on the type of meat.

Other Components: Meat also contains other components in smaller amounts, such as carbohydrates, cholesterol, enzymes, pigments, and flavor compounds. These components contribute to the overall sensory characteristics and nutritional profile of meat.

10.4. Post mortem changes:

It encompass a series of intricate biochemical and physical transformations that occur in muscle tissue following the slaughter of an animal. These changes arise from a combination of metabolic processes, enzymatic activity, and interactions among various components of the muscle. Immediately after slaughter, the absence of oxygen triggers anaerobic conditions, leading to the dominant utilization of glycogen through glycolysis, resulting in the production of lactic acid and subsequent post-mortem acidification. Shortly thereafter, rigor mortis sets in as actin and myosin filaments interact, causing muscle stiffness. Endogenous proteases like calpains and cathepsins initiate proteolysis, breaking down myofibrillar proteins and ultimately affecting meat tenderness. Simultaneously, lipolysis takes place, involving the enzymatic hydrolysis of fat into free fatty acids, which can influence meat flavor. The exposure of meat to oxygen post-slaughter can induce oxidative reactions, leading to color changes, flavor deterioration, and the generation of off-flavors and off-odors. Additionally, if not properly handled and stored, meat can be susceptible to microbial growth, resulting in spoilage and the production of undesirable compounds. Managing these post-mortem changes through appropriate handling, processing, and storage practices is crucial to maintain the desired quality attributes of meat.

10.5. Ageing

Ageing of meat refers to the controlled process of storing meat under specific conditions to enhance its tenderness, flavor, and overall quality. It involves the natural enzymatic and biochemical changes that occur in meat after slaughter. Here are the details of the ageing process:

Pre-rigor vs. Post-rigor ageing: Ageing can be performed either in the pre-rigor phase, immediately after slaughter, or in the post-rigor phase, after the completion of rigor mortis. Pre-rigor ageing is typically applied to certain types of meat, such as poultry, while post-rigor ageing is more common in beef, lamb, and pork.

Enzymatic activity: During ageing, endogenous enzymes in the meat, such as calpains and cathepsins, gradually break down the muscle proteins. This process, known as proteolysis, helps tenderize the meat by degrading connective tissue proteins and promoting the relaxation of muscle fibers.

Post-mortem changes: Ageing allows for the continuation of post-mortem changes that began immediately after slaughter. These changes include the breakdown of glycogen to lactic acid, pH decline, and the development of desirable flavor compounds. Ageing also contributes to the development of unique aromas, which enhance the overall sensory experience of the meat.

Duration and conditions: The duration of ageing can vary depending on the desired outcome and the type of meat. Typically, beef is aged for several days to weeks, whereas lamb and pork may be aged for a shorter period. Ageing can take place under specific temperature and humidity conditions, often in controlled environments such as refrigerated rooms or dry-aging chambers.

Effects on tenderness: One of the primary benefits of ageing is the improvement in meat tenderness. Proteolysis and enzymatic activity during ageing break down the muscle fibers, making them more tender and easier to chew. The breakdown of collagen, a connective tissue protein, also contributes to increased tenderness.

Flavor development: Ageing allows for the development and intensification of flavors in the meat. The breakdown of proteins during proteolysis releases amino acids and peptides, which contribute to the development of desirable flavors. Additionally, lipid oxidation and the breakdown of fats during ageing can enhance the aroma and taste of the meat.

Dry-aging vs. Wet-aging: Two common methods of ageing are dry-aging and wet-aging. Dry-aging involves hanging the meat in a controlled environment with controlled temperature, humidity, and air circulation. This process leads to the evaporation of moisture from the meat, concentrating flavors and intensifying taste. Wet-aging, on the other hand, involves vacuum-sealing the meat and aging it in its own juices, which helps retain moisture and can result in a milder flavor profile.

10.6. Processing preservation and their effects:

The processing of meat involves various techniques and methods that transform raw meat into processed meat products. These processes can have several effects on the meat, including changes in sensory attributes, nutritional composition, safety, and shelf life. Here are some common processing methods and their effects:

Grinding and Mixing:

Grinding involves reducing meat into smaller particles, while mixing combines different ingredients like spices, additives, and extenders with the meat. These processes improve the texture and homogeneity of the meat product. However, excessive grinding and mixing can lead to protein denaturation and affect the final texture and juiciness of the product.

Forming and Shaping:

Forming and shaping processes shape the ground meat mixture into specific forms such as patties, sausages, or nuggets. These processes enhance the convenience and appearance of the final product. However, mechanical forces involved in shaping can affect the meat's protein structure, leading to changes in texture and juiciness.

Curing:

Curing involves the addition of salts, nitrates, nitrites, and other curing agents to meat. Curing enhances flavor development, color stability, and inhibits the growth of bacteria, particularly Clostridium botulinum. However, excessive consumption of nitrites and nitrates may form potentially harmful compounds like nitrosamines.

Smoking:

Smoking exposes meat to smoke derived from burning wood or other materials. Smoking imparts a characteristic smoky flavor, enhances shelf life by reducing water content, and inhibits bacterial growth due to antimicrobial compounds present in smoke. However, improper smoking can lead to the formation of harmful compounds like polycyclic aromatic hydrocarbons (PAHs).

Cooking and Heat Processing:

Cooking and heat processing methods, such as grilling, roasting, boiling, or canning, apply heat to meat to enhance safety, extend shelf life, and improve sensory attributes. Heat denatures proteins, modifies texture, and enhances flavor and aroma. However, excessive heat processing can lead to nutrient loss and affect sensory attributes.

Fermentation and Culturing:

Fermentation involves the controlled growth of specific bacteria or fungi on the meat surface, promoting desirable microbial activities. Fermentation lowers the pH, inhibiting the growth of spoilage bacteria and contributing to flavor development. However, it can also lead to changes in texture and aroma due to the breakdown of proteins and carbohydrates.

Packaging and Storage:

Packaging and storage methods, such as vacuum packaging, modified atmosphere packaging (MAP), or canning, protect the processed meat from spoilage microorganisms and oxidation. Proper packaging and storage conditions help maintain the quality, safety, and shelf life of the product by controlling microbial growth and preventing chemical reactions.

The preservation of meat aims to inhibit the growth of microorganisms, slow down enzymatic reactions, and delay the spoilage and degradation processes. Various preservation methods are employed, each with its own effects on meat. Here is a detailed explanation of the preservation methods and their effects:

Refrigeration:

Refrigeration involves storing meat at temperatures between 0°C and 4°C. The low temperatures inhibit the growth of most spoilage microorganisms and slow down enzymatic activities. Refrigeration helps maintain the sensory attributes, such as color, texture, and flavor of the meat, although gradual quality deterioration can still occur over time. The shelf life of refrigerated meat can range from a few days to several weeks, depending on factors like initial quality, storage conditions, and microbial load.

Freezing:

Freezing is a preservation method that involves lowering the temperature of meat to below -18°C. Freezing forms ice crystals, reducing the water activity and inhibiting microbial growth. It effectively extends the shelf life of meat by several months to years, depending on the storage temperature and packaging. However, freezing can cause changes in the meat's texture, especially upon thawing, resulting in potential quality loss. Freezing can also lead to the formation of ice crystals that may rupture meat cells, affecting its juiciness and tenderness.

Canning:

Canning involves heat processing meat in a hermetically sealed container to destroy microorganisms and enzymes. This method provides long shelf life, as it creates a sterile environment inside the container, preventing recontamination. Canned meat retains its nutritional value and sensory attributes for an extended period, but the texture may be softer due to the heat processing.

Drying:

Drying is a preservation method that involves removing moisture from meat to inhibit microbial growth. This process can be achieved through air drying, sun drying, or using specialized drying equipment. Dried meat products, such as jerky or biltong, have a significantly extended shelf life, as the reduction in water activity inhibits microbial activity. However, drying can lead to changes in texture, making the meat tougher, and may also cause some loss of nutrients.

Heat processing:

Heat processing methods, such as cooking, boiling, or canning, involve applying heat to meat to destroy pathogenic microorganisms and enzymes, thereby enhancing its safety and extending shelf life. Heat denatures proteins, modifies the meat's texture, and enhances its flavor and aroma. However, excessive heat processing can lead to the loss of some heat-sensitive nutrients and may affect the sensory attributes of meat.

It's important to note that the effects of preservation and processing methods can vary depending on the specific techniques used, the quality of meat, storage conditions, and the duration of preservation. Scientific research and food safety regulations continuously evaluate these methods to ensure the production of safe and high-quality meat products.

10.7. Heat induced changes in meat:

Heat-induced changes in meat refer to the transformations that occur in meat when it is subjected to cooking or heat processing. These changes involve various chemical, structural, and sensory alterations. Heating meat causes the denaturation of proteins, resulting in changes to their structure and properties. Denaturation involves the disruption of protein bonds and the unfolding of protein chains, leading to a loss of the protein's original structure and functionality. It causes moisture to evaporate from the meat, resulting in water loss during cooking. This can lead to changes in meat texture, as dehydration can cause meat to shrink and become firmer. The browning of meat occurs resulting in the flavor and aroma development. It gives meat its characteristic brown crust and contributes to the desirable savory flavors associated with cooked meat. It also causes the melting and rendering of fat. Fat begins to liquefy, and the heat facilitates the separation of fat from the surrounding tissue. This can enhance the juiciness and flavor of the cooked meat. Initially, collagen is tough and fibrous, but with prolonged heat exposure, it gradually converts into gelatin. This process, known as collagen breakdown, contributes to the tenderization of meat and the development of a more desirable texture.

10.8. Tenderizers meat products

Tenderizers are substances or methods used to enhance the tenderness of meat by breaking down its connective tissues and proteins. They help to reduce the toughness and improve the palatability of meat. Here are some commonly used tenderizers:

Enzymatic Tenderizers: These tenderizers contain natural enzymes that break down proteins in meat. Papain, derived from papaya, and bromelain, derived from pineapple, are examples of enzymatic tenderizers. These enzymes specifically target collagen, a tough connective tissue protein, and help to tenderize meat by breaking it down into smaller, more tender fragments.

Mechanical Tenderizers: Mechanical tenderizing methods involve physically breaking down the muscle fibers and connective tissues in meat. This can be achieved by using tools like meat mallets, tenderizing machines, or knives to create small cuts or punctures in the meat, which disrupts the muscle structure and results in increased tenderness.

Chemical Tenderizers: Certain chemicals can be used as tenderizers. Salt is a common chemical tenderizer that works by altering the protein structure, allowing it to retain moisture and become more tender. Other substances such as baking soda (sodium bicarbonate) and vinegar (acetic acid) can also be used as chemical tenderizers by altering the pH of the meat and facilitating protein breakdown.

Marinating: Marinating involves soaking meat in a liquid mixture, typically containing acidic ingredients like citrus juice, vinegar, or wine, along with herbs, spices, and other flavorings. The acid in the marinade helps to break down muscle fibers and proteins, contributing to increased tenderness.

Aging: Aging is a natural tenderizing process that involves storing meat under controlled conditions for a specific period. During this time, endogenous enzymes break down the connective tissues and proteins, resulting in improved tenderness. Dry-aging, where meat is stored in a controlled environment with controlled humidity, or wet-aging, where meat is vacuum-sealed and aged in its own juices, are common methods of aging meat.

10.9. Meat products:

Meat products refer to food items that are derived from meat or meat by-products through various processing techniques. These products undergo specific treatments, additives, or combinations with other ingredients to create a wide range of food options. Here are some common types of meat products:

Sausages: Sausages are ground meat mixed with spices, seasonings, and often fat, stuffed into casings (natural or artificial). They can be made from a variety of meats such as pork, beef, chicken, or a combination of meats. Sausages can be cooked by grilling, frying, or boiling.

Bacon: Bacon is a cured and smoked meat product typically made from pork belly. It is sliced and often fried or grilled before consumption. Bacon is known for its distinctive flavor and is used in a variety of dishes and sandwiches.

Ham: Ham is a preserved meat product made from the hind leg of a pig. It is usually cured, smoked, or both. Ham can be consumed cooked or uncooked, and it is commonly sliced and used in sandwiches or cooked as a centerpiece for meals.

Deli Meats: Deli meats, also known as cold cuts or luncheon meats, are thinly sliced or processed meats commonly used in sandwiches and salads. They include various options such as roast beef, turkey, ham, salami, and bologna.

Poultry Products: Chicken and turkey are commonly processed into different meat products. Examples include chicken nuggets, chicken sausages, turkey burgers, and turkey bacon. These products often involve grinding, shaping, and seasoning the meat.

Processed Meats: Processed meats are made by combining various meats or meat by-products with additives, seasonings, and preservatives. These can include products like hot dogs, meatballs, meatloaf, and canned meats. Processing methods may involve grinding, emulsifying, cooking, and packaging.

Jerky: Jerky is a dried meat product that is typically lean and thinly sliced. It is seasoned and cured with salt, sugar, and spices before undergoing a drying process. Jerky can be made from beef, pork, poultry, or even exotic meats like venison or buffalo.

Meat-based Ready Meals: Ready meals or convenience meals often contain meat as a key component. These products can include meat lasagna, meat pies, meatballs in sauce, and other prepared dishes that require minimal cooking or reheating.

10.10. Eggs

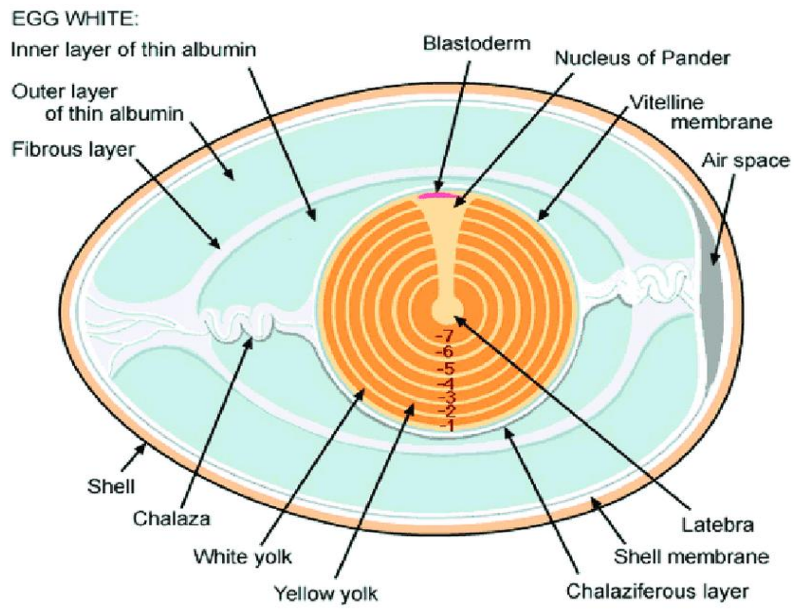


Fig 2: Structure of an egg

Source: Adegbenjo, Adeyemi & Liu, Laura & Ngadi, Michael. (2020). Non-Destructive Assessment of Chicken Egg Fertility. Sensors. 20. 5546.

Structure:

The shell of a chicken egg is the outermost layer that provides protection and support for the egg contents. It is primarily composed of calcium carbonate ($CaCO_3$) in the form of tiny crystals arranged in a complex lattice structure.

The process of shell formation, known as calcification. Specialized cells in the shell gland secrete proteins and minerals that form the shell. Initially, a thin, protein-based layer called the cuticle or bloom is deposited on the egg's surface. This cuticle helps to seal the shell pores and reduce moisture loss and bacterial contamination.

Underneath the cuticle, the main shell is formed in two distinct layers: the outer shell membrane and the inner shell membrane. The shell membranes are primarily composed of fibrous proteins, mainly keratin, arranged in a network that provides strength and flexibility to the shell. These membranes act as additional barriers against the entry of microorganisms into the egg.

The shell itself is porous, containing thousands of microscopic pores. These pores allow for the exchange of gases, primarily oxygen and carbon dioxide, between the interior of the egg and the external environment. The size and number of pores can vary among different egg-laying species, with chicken eggshells having an average of about 7,000 to 17,000 pores.

The shell's porous nature allows the developing embryo to obtain oxygen and release carbon dioxide during incubation. However, the shell's porosity also makes the egg susceptible to water loss and the potential penetration of microorganisms, which is why the shell membranes and cuticle play crucial roles in protecting the egg from contamination.

Egg White: The egg white, also known as the albumen or egg white proper, is the clear, viscous substance that surrounds the yolk of a chicken egg. It constitutes the majority of the egg's liquid content and serves various important functions.

Egg yolk: The egg yolk is the yellow, circular portion of a chicken egg that is suspended within the egg white (albumen). It is rich in nutrients and serves as a nutrient reserve for the developing embryo or, in unfertilized eggs, as a source of essential nutrients for human consumption. The egg yolk is surrounded by a thin membrane called the vitelline membrane. This membrane acts as a protective barrier for the yolk.

Inside the yolk, there is a small circular region on its surface known as the germinal disc or blastodisc. The germinal disc contains the genetic material necessary for embryo development if the egg is fertilized.

The chalaza are two spiral, rope-like structures made up of twisted strands of egg white proteins (albumen). They extend from opposite ends of the yolk and anchor it in the center of the egg. The chalaza play a crucial role in keeping the yolk positioned and centered within the egg, allowing for even distribution of nutrients and protection during movement.

10.11. Composition

Egg white: The egg white is primarily composed of water, accounting for about 88% of its total weight. It also contains proteins, vitamins, minerals, and small amounts of carbohydrates and fats. The proteins found in the egg white include:

a. **Ovalbumin:** Ovalbumin is the most abundant protein in the egg white, comprising about 54% of the total protein content. It is a globular protein that provides structure and acts as a source of amino acids for the developing embryo.

b. **Ovotransferrin:** Ovotransferrin, also known as conalbumin, is an iron-binding protein that helps transport iron within the egg and provides protection against microbial growth by limiting the availability of iron to potential pathogens.

c. **Ovomucin:** Ovomucin is a glycoprotein that contributes to the gel-like consistency of the egg white. It helps to maintain the structural integrity and stability of the egg white by forming a network of interlinked molecules.

d. **Lysozyme:** Lysozyme is an enzyme that possesses antibacterial properties. It helps to protect the egg against microbial contamination by breaking down the cell walls of certain bacteria

Egg yolk:

a. **Triglycerides:** The primary lipid component of egg yolk is triglycerides, which are esters formed from glycerol and fatty acids. Triglycerides serve as a concentrated energy source for the developing embryo. The fatty acid composition of yolk triglycerides can vary, including saturated, monounsaturated, and polyunsaturated fatty acids.

b. **Phospholipids:** Egg yolk contains phospholipids, including phosphatidylcholine, phosphatidylethanolamine, and phosphatidylserine. Phospholipids are essential for cell membrane formation and play a role in emulsification and stabilization of fat droplets.

c. **Cholesterol:** Egg yolk is rich in cholesterol, which is a sterol involved in cell membrane structure and the production of hormones and bile acids. Cholesterol in the yolk serves as a precursor for the synthesis of various biologically active compounds.

Proteins:

a. Vitellogenin: The major protein component of egg yolk is vitellogenin. It is synthesized in the liver and transported to the developing oocyte (egg) to provide a source of amino acids for embryonic development.

b. Lipoproteins: Egg yolk contains lipoproteins such as high-density lipoproteins (HDL), low-density lipoproteins (LDL), and very low-density lipoproteins (VLDL). These lipoproteins are involved in lipid transport and metabolism.

c. Other Proteins: Egg yolk also contains other proteins, such as phosvitin, livetin, and various enzymes.

Pigments present in eggs contribute to the coloration of different parts of the egg, including the shell, egg white, and egg yolk. Here are the pigments commonly found in different parts of the egg:

Pigments

Shell Pigments:

a. Brown Pigments: Brown pigments, such as protoporphyrin and biliverdin, are responsible for the brown coloration of some eggshells. These pigments are derived from the breakdown of heme, a component of hemoglobin.

b. Blue/Green Pigments: Blue or green pigments, such as biliverdin and oocyanin, contribute to the coloration of eggs with blue or green shells. These pigments are produced by specific cells in the shell gland.

The egg white, also known as the albumen, is typically colorless or pale yellow in its natural form. It does not contain significant pigments that contribute to its color.

Egg Yolk Pigments:

a. **Xanthophylls:** Xanthophylls are yellow pigments that contribute to the yellow color of the egg yolk. The primary xanthophylls found in egg yolk are lutein and zeaxanthin. These pigments are derived from the hen's diet, primarily from plant sources.

b. **Carotenoids:** Carotenoids, including beta-carotene, canthaxanthin, and others, can also contribute to the coloration of egg yolks. These pigments are converted to vitamin A in the body and can range in color from yellow to red-orange, depending on the specific carotenoid.

The presence and concentration of pigments in eggs can vary depending on factors such as the breed of the hen, diet, and genetics. For example, specific chicken breeds are known for laying eggs with distinct shell colors, such as brown or blue. The pigments in the egg yolk are influenced by the hen's diet, with a more varied diet often resulting in a richer and deeper coloration of the yolk.

Water: Although the egg yolk is semisolid, it contains a small percentage of water, contributing to its overall composition. Egg yolk is a rich source of various vitamins, including fat-soluble vitamins such as vitamin A (retinol and carotenoids), vitamin D (cholecalciferol), vitamin E (tocopherols and tocotrienols), and vitamin K (phylloquinone and menaquinones). These vitamins have important roles in vision, bone health, antioxidant activity, and blood clotting.

Minerals: Egg yolk contains essential minerals, including iron, phosphorus, selenium, zinc, copper, and others. These minerals are involved in various physiological processes and play important roles in enzyme function, bone health, and antioxidant defense.

Bioactive Compounds: Egg yolk also contains bioactive compounds such as carotenoids (lutein and zeaxanthin), which are natural pigments with antioxidant properties. These compounds may have potential health benefits, including promoting eye health and reducing the risk of certain chronic diseases.

10.12. Changes during the storage

During the storage of eggs, several changes can occur due to various factors such as temperature, humidity, and the age of the egg. Here are some of the common changes that can take place during egg storage:

- **Loss of Moisture**: Eggs contain a small amount of moisture, and over time, they can lose some of this moisture through the pores in the eggshell. As a result, the egg may shrink slightly, and the air cell inside the egg may expand.

- **Carbon Dioxide Accumulation:** As eggs age, they naturally release carbon dioxide through the shell pores. This accumulation of carbon dioxide can cause the egg white to become more acidic, which affects its texture and whipping properties.
- **Quality Changes**: As eggs age, their quality gradually declines. The egg white becomes thinner and more fluid, while the yolk may flatten and lose some of its firmness. This change in texture can affect the overall appearance and cooking properties of the egg.
- **pH Changes:** The pH of the egg white increases during storage due to the loss of carbon dioxide. This increase in pH can affect the stability and functionality of proteins in the egg white, particularly when used for baking or whipping.
- **Shell Integrity:** The quality of the eggshell can also be affected during storage. As the egg ages, the shell may become more fragile and prone to cracking or breaking. Proper handling and storage conditions can help minimize shell damage.
- **Odor Changes:** As eggs age, they can develop a slight sulfur-like odor. This odor is caused by the breakdown of proteins in the egg white, resulting in the release of volatile sulfur compounds.

10.13. Functional properties of eggs used in cookery

Eggs possess several functional properties that make them valuable ingredients in cookery. Here are some of the key functional properties of eggs:

- **Binding:** Eggs act as binders in recipes, helping to hold ingredients together. The proteins in eggs coagulate when exposed to heat, creating a solid network that binds the ingredients in baked goods, custards, and meatloaf, among others.

- Emulsifying: Egg yolks contain lecithin, a natural emulsifier that helps mix and stabilize oil and water-based ingredients that would otherwise separate. This property is crucial in making mayonnaise, salad dressings, and sauces.
- **Foaming and Leavening:** Egg whites can be beaten to create foam due to their high protein content. This foaming ability is important for creating volume and lightness in recipes such as meringues, soufflés, and sponge cakes. The trapped air bubbles in the foam expand during baking, resulting in a light and airy texture.
- **Thickening:** Egg yolks contribute to the thickening of sauces, custards, and creams due to the proteins and natural starches they contain. The heat causes the proteins to coagulate and thicken the liquid, providing a smooth and creamy consistency.
- **Coating and Glazing:** Beaten eggs, often referred to as an egg wash, are used to coat or glaze the surface of baked goods. This creates a glossy and golden appearance while also helping to bind toppings such as breadcrumbs.
- **Moisture Retention:** Eggs contribute to the moisture retention in baked goods, preventing them from becoming dry and maintaining a tender texture. The fats and proteins in eggs help to trap and hold moisture during baking.
- **Color and Appearance:** Eggs add color and richness to baked goods, giving them a golden or yellow hue. They contribute to the overall visual appeal of dishes, making them more appetizing.

These functional properties of eggs make them versatile and indispensable in various cooking and baking applications, providing structure, texture, and flavor enhancement to a wide range of recipe

10.14. Egg cookery

Egg cookery refers to the various methods and techniques used to prepare eggs as a food ingredient. Eggs are incredibly versatile and can be cooked in numerous ways, each resulting in different textures and flavors. Here are some common methods of egg cookery:

Boiling: Eggs can be boiled to achieve different levels of doneness. Soft-boiled eggs have a runny yolk, while hard-boiled eggs have a fully set yolk.

Poaching: Poached eggs are cooked gently in simmering water. The result is a tender egg with a runny yolk. Poached eggs are commonly used in dishes like Eggs Benedict.

Frying: Eggs can be fried in a skillet with butter or oil. Sunny-side up eggs are cooked on one side, with the yolk still runny. Over-easy eggs are flipped and cooked briefly on the other side to set the yolk slightly.

Scrambling: Scrambled eggs involve beating the eggs and cooking them in a pan with butter or oil. They can be cooked until firm or left slightly runny, depending on personal preference.

Baking: Eggs can be used in baking recipes to add moisture and structure to various dishes like cakes, cookies, and custards.

Omelets: Omelets are made by whisking eggs and cooking them in a pan with various fillings, such as vegetables, cheese, or meats. They are typically folded over to enclose the fillings.

Steaming: Steamed eggs are delicate and have a silky texture. They are made by gently whisking eggs, mixing them with liquid (such as broth or water), and steaming the mixture until set.

These are just a few examples of egg cookery techniques. Eggs can be prepared in many other ways, such as in soufflés, quiches, and frittatas. The method chosen often depends on personal preference and the desired outcome for the dish being prepared.

10.15. Let us sum up

Meat and meat products are an essential part of the human diet and have been consumed for thousands of years. From a food science perspective, meat refers to the edible tissues of animals, primarily mammals that are consumed as food. Meat products, on the other hand, are processed or manufactured food items made from meat or meat by-products. It is composed of various components, including muscle fibers, connective tissues, fat, water, and minerals. The composition can vary depending on the species, age, breed, and diet of the animal. It valuable source of high-quality protein, essential amino acids, vitamins (such as B vitamins and vitamin D), minerals (such as iron and zinc), and fats. It provides important nutrients for growth, development, and overall health. After an animal is slaughtered, biochemical and physiological changes occur in the meat. These changes can affect the flavour, tenderness, and colour of the meat. Post-mortem processes like rigor mortis, aging, and enzymatic activities play a role in meat quality. It can undergo various processing techniques to produce meat products with different textures, flavours, and shelf lives. These techniques include cutting, grinding, curing, smoking, marinating, cooking, and packaging. Processing can enhance the safety, taste, and convenience of meat products. It involves specific considerations for food safety. Microorganisms like bacteria, parasites, and viruses can be present in raw meat and can cause foodborne illnesses if not properly handled, cooked, or stored. Proper hygiene practices, temperature control, and effective preservation methods are essential for ensuring meat safety.

Chicken eggs are typically oval-shaped and covered by a hard outer shell composed mainly of calcium carbonate. The shell serves as a protective barrier against physical damage and bacterial contamination. The hard, outer covering of the egg that provides protection. Shell membrane is Located just beneath the shell, it serves as an additional barrier against bacteria. Albumen (egg white) is a clear, viscous fluid surrounds the yolk and acts as a cushioning agent, providing moisture and protein to the developing embryo. Yolk is a yellow or orange part of the egg, rich in proteins, fats, and nutrients. The yolk serves as the food source for the developing chick and contains vitamins, minerals, and cholesterol. Two twisted, rope-like strands of albumen that anchor the yolk in place within the egg is known as Chalaza. Germinal disc (blastodisc) is Located on the surface of the yolk, this small circular spot contains the genetic material necessary for the development of an embryo if the egg is fertilized. It's worth noting that there are different sizes of chicken eggs, including small, medium, large, and extra-large, based on the weight of the eggs. Overall, chicken eggs are a versatile and widely consumed food item that provides essential nutrients, including high-quality proteins, vitamins, and minerals.

10.16. Glossary

- **Adipose tissue:** Connective tissue composed of fat cells (adipocytes) that store energy in the form of fat and serve as insulation, cushioning, and a source of fuel for the body.
- **Actin:** Actin is a protein found in all eukaryotic cells and plays a vital role in cellular processes such as muscle contraction, cell division, and cell movement. It forms thin filaments and interacts with myosin to generate force and movement.
- **Connective tissue:** Supports and connects body structures, ensuring the integrity and function of organs and tissues by providing structural support, protection, and transportation of nutrients and waste materials.
- **Curing:** The process of preserving and flavoring food through techniques like salt, sugar, or nitrite application, which inhibit microbial growth, enhance flavor, and modify texture.

- **Elastin protein:** Provides elasticity to tissues; less desirable in cooking due to toughness, requiring special techniques for tenderization
- **Foam:** A mixture of air bubbles trapped in a liquid or solid substance, creating a light and airy texture.
- **Lipoprotein:** Protein-lipid complexes that transport cholesterol and triglycerides in the bloodstream, with different types like LDL, HDL, and VLDL, impacting cardiovascular health.
- **Marbling in meat:** Intramuscular fat that appears as white streaks or flecks within the muscle, enhancing flavor, juiciness, and tenderness.
- **Marinating:** Soaking food in a seasoned liquid to enhance flavor, tenderize, and improve texture.
- **Myosin:** Myosin is a protein primarily found in muscle cells. It forms thick filaments and works in conjunction with actin to produce muscle contractions. Myosin utilizes ATP energy to generate force and facilitate muscle movement.
- **Pigments:** Natural compounds that provide color to living organisms or food, enhancing visual appeal and potentially offering health benefits.
- **Rigor mortis:** Post-mortem muscle stiffening caused by the inability of actin and myosin to detach due to ATP depletion after death.
- **Smoking:** A culinary technique where food is exposed to smoke from burning wood or other materials. It adds flavor, imparts a smoky aroma, and can help preserve and cook the food simultaneously.

10.17. CHECK YOUR PROGRESS EXERCISE

Fill in the blanks:

a) The muscle fibers are organized into bundles known as ………………, which are held together by connective tissue
b) The ………………….surrounds individual muscle fibers, providing support and insulation.
c) ……………………… a sarcoplasmic protein, is responsible for the red color of meat and its ability to bind and store oxygen.
d) The shell of an egg composed of ……………………. in the form of tiny crystals arranged in a complex lattice structure.
e) ………………..helps to protect the egg against microbial contamination by breaking down the cell walls of certain bacteria
f) The ………….. allow for the exchange of gases, primarily oxygen and carbon dioxide, between the interior of the egg and the external environment.
g) The shell membranes are primarily composed of ………………arranged in a network that provides strength and flexibility to the shell.
h) …………………..contribute to the coloration of egg yolks.
i) …………….helps to maintain the structural integrity and stability of the egg white by forming a network of interlinked molecules.
j) The egg yolk is surrounded by a thin membrane called the ………………… which acts as a protective barrier.
k) ………………… is the most abundant protein in the egg white, comprising about 54% of the total protein content.
l) The ………….. helps to seal the shell pores and reduce moisture loss and bacterial contamination.
m) The ………………….. is a small circular region on the yolk surface contains the genetic material necessary for embryo development if the egg is fertilized.
n) The …………….. play a crucial role in keeping the yolk positioned and centered within the egg, allowing for even distribution of nutrients and protection during movement.
o) ………………………, is an iron-binding protein that helps transport iron within the egg and provides protection against microbial growth by limiting the availability of iron to potential pathogens.

p) ………………… and …………………. pigments responsible for the brown colouration of some eggshell.

One word answer:

1. Name the connective tissue that provides structural support and resilience to the muscle.

   ………………………………………………………………………………
   ……………………………………………………………………………….

2. Name the protein that is responsible for texture and contractile properties of meat.

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   ……………………………………………………………………………….

Short answer type question:

1. Explain briefly the composition of meat.

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2. With the help of neat diagram explain the structure of meat.

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3. Enlist the Heat induced changes in meat.

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4. Name some chemical tenderizers that is used to reduce the toughness and improve the palatability of meat.

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5. Discuss the Post mortem changes in meat.

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6. State the Functional properties of eggs used in cookery.

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7. Define the following terms:

a) Smoking

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b) Marbling

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………………………………………………………………………

c) Curing

………………………………………………………………………

…………………………………………………………………

10.17. Answer key

a. Calcium Carbonate
b. Lysozyme
c. Shell pores
d. Keratin
e. Carotenoids
f. Ovomucin
g. vitelline membrane
h. Ovalbumin
i. Cuticle
j. germinal disc
k. chalaza
l. Ovotransferrin
m. protoporphyrin and biliverdin

UNIT 11: FISH AND SEA FOODS: TYPES COMPOSITION FISH STORAGE AND CHANGES DURING STORAGE

11.1. Introduction

In the previous unit we learnt about the egg, meat and poultry fish. In this unit, we will learn about the composition and nutritive value of fish. It is a nutritious food with high protein content, essential fatty acids, vitamins, and minerals. We will discussed the Proper selection, handling, and storage of fish as they are important to ensure freshness and prevent spoilage. Lastly we will study about the various preservation methods that can be employed to extend the shelf life of fish while maintaining its nutritional value.

Objectives

You will be able to:

- Learn about the classification and composition of fish.
- Comprehend the Selection criteria of fish
- Learn about the fish cookery and spoilage.

- Understand the preservation and storage of fish.

Fish are aquatic vertebrates that belong to the group of animals called Pisces. They are cold-blooded animals with gills, which enable them to extract oxygen from water. Fish have played a crucial role in human nutrition and food security for thousands of years. Fish are an excellent source of high-quality protein, essential omega-3 fatty acids, vitamins, and minerals. They are also low in saturated fats, making them a healthier alternative to red meat. Fish have also been an important part of cultural and culinary traditions, with various species of fish featuring prominently in the cuisines of different regions. For example, salmon is a staple food in many indigenous communities in the Pacific Northwest of North America, while tilapia is a common ingredient in West African cuisine. With the growing global population and increasing demand for food, aquaculture, or fish farming, has become an essential source of fish production. Fishing has been a traditional occupation and recreational activity in many cultures, and fish farming (aquaculture) has become increasingly significant in meeting the global demand for fish. For example, indigenous communities in North America and coastal communities in Africa and Asia have relied on fishing as a primary source of food and income for generations.

11.2. Classification

Edible fish can be classified based on various factors such as their habitat, culinary characteristics, and commercial significance. Here is a general classification of edible fish based on their characteristics:

Whitefish: Whitefish are a group of lean fish with light-colored flesh. They are often mild in flavor and have a delicate texture. Examples include cod, haddock, pollock, and sole.

Oily Fish: Oily fish are characterized by their high oil content, which gives them a rich flavor and moist texture. They are also a good source of omega-3 fatty acids. Examples of oily fish include salmon, trout, mackerel, sardines, and tuna.

Shell fish: Shellfish are aquatic animals with shells and include various types of mollusks and crustaceans. They are highly valued for their flavor and are often enjoyed as seafood delicacies. Examples of shellfish include shrimp, crab, lobster, oysters, mussels, and clams.

Flat fish: Flatfish have a distinctive flattened body shape and both eyes on one side of their head. They are known for their mild, sweet flavor and are commonly used in dishes such as sole meunière or flounder fillets. Examples include flounder, sole, halibut, and plaice.

Pelagic Fish: Pelagic fish are typically found in the open water and inhabit the upper layers of the ocean. They are known for their migratory behavior and include species such as tuna, mahi-mahi, swordfish, and bonito. They are often known for their firm texture and bold flavor.

Freshwater Fish: Freshwater fish inhabit rivers, lakes, and other freshwater bodies. They encompass a wide range of species with varying flavors and textures. Examples include trout, catfish, pike, walleye, and tilapia.

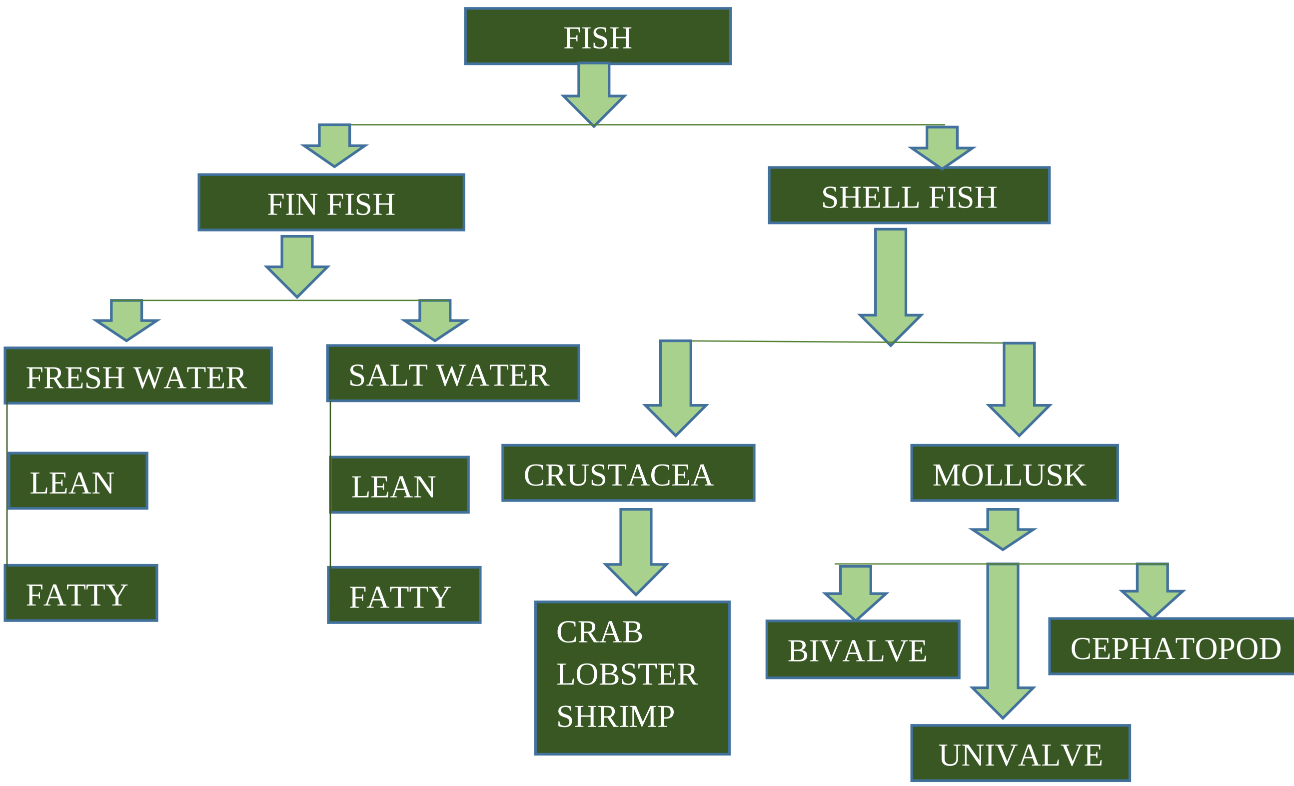

Fig 1: CLASSIFICATION OF FISH

11.3. Composition and Nutritional value

The composition of fish can be described in detail using scientific terminology. Here is a breakdown of the key components found in fish:

Water: Fish typically have a high water content, ranging from 65% to 85% depending on the species, freshness, and habitat.

Proteins: Fish are known for being an excellent source of high-quality protein. The protein content in fish can vary depending on the species, size, and freshness. The protein content of fish varies among species but generally ranges from 15% to 25%. Fish proteins are particularly rich in essential amino acids like lysine, methionine, tryptophan, and leucine. The protein in fish is regarded as high quality due to its excellent amino acid profile and high digestibility. It contains a balanced ratio of essential amino acids, making it a valuable protein source for meeting dietary requirements. Oily fish like salmon and mackerel tend to have slightly higher protein content compared to lean fish species like cod or sole. Additionally, protein content can vary within the same species depending on factors such as size, age, and habitat.

It is highly regarded for its nutritional value and its contribution to a balanced diet. It serves as a valuable source of essential amino acids, supporting various bodily functions including muscle growth and repair, enzyme synthesis, and immune function.

Lipids (Fats): Fish contain varying amounts of lipids, or fats, which contribute to their flavor, texture, and nutritional value. The lipid content in fish can range from 0.5% to 30%, with oily fish generally having higher lipid levels. Different fish species exhibit significant variations in their fat content. Fish lipids are primarily composed of triglycerides, phospholipids, and cholesterol. It contains the combination of different types of fatty acids, including saturated, monounsaturated, and polyunsaturated fatty acids. Oily fish, such as salmon and mackerel, are known for their high levels of beneficial omega-3 fatty acids, specifically eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These are long-chain polyunsaturated fatty acids that have been linked to numerous health benefits, including cardiovascular health, brain function, and reducing inflammation. It also contain omega-6 fatty acids, although in relatively lower quantities compared to omega-3 fatty acids.

The consumption of fish, particularly fatty fish, has been associated with various health benefits due to its omega-3 fatty acid content. These benefits include reducing the risk of heart disease, improving cognitive function, and supporting eye health.

Carbohydrates: Fish typically contain minimal amounts of carbohydrates, generally less than 1%. Carbohydrates in fish are primarily found in the form of glycogen, a storage form of glucose. Shellfish such as shrimp, crabs, and lobsters, are typically leaner in terms of fat content, while fin fish, such as salmon and mackerel, often contain higher levels of fats, including beneficial omega-3 fatty acids. On the other hand, shellfish have relatively higher carbohydrate content in the form of glycogen.

Minerals: Fish are a good source of various essential minerals, including calcium, phosphorus, potassium, magnesium, selenium, and iodine. These minerals play important roles in bone health, nerve function, and enzymatic activities in the human body.

Vitamins: Fish are a natural source of vitamins, particularly B-complex vitamins such as thiamin (B1), riboflavin (B2), niacin (B3), pyridoxine (B6), and cobalamin (B12). Fish, especially oily fish like salmon and mackerel, contain vitamin A in the form of retinol. Fatty fish, such as salmon, tuna, and sardines, are known for their high vitamin D content.

Fish, particularly oily fish, are also a significant source of fat-soluble vitamins, including vitamin A, vitamin D, and vitamin E.

Other Components: Fish may contain other components, such as pigments (e.g., astaxanthin giving salmon its pink color), antioxidants, and bioactive compounds like peptides and polyphenols. These compounds have been studied for their potential health benefits, including antioxidant and anti-inflammatory properties.

11.4. Selection of fish

When selecting fish for consumption, it is important to consider several factors to ensure optimal quality, freshness, and sustainability.

Freshness Indicators: Assess the freshness of the fish by examining its sensory characteristics. Look for clear, bright eyes; moist and shiny skin; and firm, elastic flesh. The gills should be vibrant in color, ranging from red to pink, indicating proper oxygenation.

Assess the freshness of shellfish by examining their sensory characteristics. Live shellfish should have tightly closed shells or close immediately when tapped. Avoid shellfish with open shells, as it may indicate spoilage or poor quality. Additionally, the shells should be intact and free from cracks or chips.

Quality Assessment: Examine the overall quality of the fish. Check for intact scales and undamaged skin. The flesh should be free from discoloration, bruises, or signs of excessive drying. It should spring back when pressed lightly, indicating its firmness and freshness.

Odor: Fresh shellfish should have a mild, briny odor reminiscent of the ocean rather than a strong or fishy. Avoid shellfish with a strong, pungent, or ammonia-like smell, as it can indicate spoilage or contamination.

Size and Weight: Consider the size and weight of the shellfish. While size doesn't necessarily determine quality, smaller shellfish tend to be more tender and flavorful. Choose shellfish that feel heavy for their size, indicating that they are plump and filled with meat.

11.5. Fish cookery

Fish flesh contains proteins that are sensitive to heat. When exposed to heat, these proteins undergo denaturation, which means they unfold and rearrange their structure. As a result, the texture and firmness of the fish flesh change. The coagulation of proteins causes the flesh to firm up and flake, which is the desired outcome in most fish preparations. Cooking fish involves managing moisture loss to prevent dryness. Fish flesh contains a significant amount of water, and heat can cause the evaporation of this water. Cooking methods that minimize moisture loss, such as steaming, poaching, or cooking in a sauce, help retain the natural juices and ensure moist and tender fish.

Different cooking methods transfer heat to fish through conduction, convection, or radiation. Conduction occurs when heat is transferred directly from a heat source (e.g., a pan) to the fish. Convection involves the transfer of heat through the circulation of hot liquids or gases (e.g., in baking or steaming). Radiation is the transfer of heat through direct exposure to a heat source (e.g., grilling). The appropriate cooking method depends on the desired texture and flavor.

Cooking methods and ingredients contribute to flavor development in fish. The amino acids and reducing sugars react at high temperatures, leads to browning, flavor formation, and the development of desirable aromas. Seasonings, herbs, spices, and marinades enhance the taste profile and complement the natural flavors of the fish. Proper cooking techniques result in the desired texture, such as a tender and flaky consistency. Overcooking can lead to dryness and toughness, while undercooking may result in a raw or chewy texture. Achieving the appropriate texture involves managing the cooking time, temperature, and heat transfer. Cooking also ensures the destruction of harmful bacteria and parasites that may be present in raw fish.

11.6. Spoilage

Spoilage of fish refers to the deterioration of fish quality, rendering it unsuitable for consumption due to changes in its physical, chemical, and microbiological characteristics. Several factors contribute to fish spoilage, including:

Microbial Growth: Bacteria, yeasts, and molds are present on fish surfaces and in their surroundings. When conditions are favorable, these microorganisms multiply rapidly, leading to spoilage. Microbial growth results in off-putting odors, slime formation, and texture changes in fish.

Enzymatic Activity: Fish contain enzymes that, if not controlled, can cause quality deterioration. Enzymes naturally present in fish can lead to changes in color, texture, and flavor. For example, the enzyme cathepsin can break down proteins, resulting in a softer texture.

Oxidation: Fish are rich in unsaturated fatty acids, which are susceptible to oxidation. Exposure to oxygen in the air can lead to rancidity, characterized by off-flavors and odors. Oxidation also causes discoloration, making the fish appear dull or yellowish.

Temperature: Fish is highly perishable and sensitive to temperature abuse. If stored at improper temperatures, such as in the temperature danger zone (between 40°F and 140°F or 4°C and 60°C), bacterial growth accelerates, leading to rapid spoilage. Heat can also accelerate enzymatic activity and lipid oxidation, further deteriorating fish quality.

Physical Damage: Physical damage, such as bruising, crushing, or rough handling, can accelerate spoilage. Damaged tissue provides a favorable environment for microbial growth and enzymatic activity. Additionally, broken skin or punctures allow for the entry of bacteria, further hastening spoilage.

Signs of fish spoilage include unpleasant odor (ammonia-like, sour, or putrid), sliminess, discoloration (dull or yellowish), changes in texture (mushy or slimy), and presence of mold or visible microbial growth.

To prevent fish spoilage, proper handling, storage, and cooking practices should be followed. This includes:

Temperature Control: Keep fish chilled at temperatures below 40°F (4°C) to slow down microbial growth and enzymatic activity. Use ice or refrigeration during storage and transportation.

Hygiene: Maintain good hygiene during fish handling to minimize the introduction of microorganisms. Clean and sanitize surfaces, utensils, and equipment used for fish preparation.

Packaging: Proper packaging, such as vacuum sealing or using airtight containers, can inhibit oxidation and reduce exposure to air and contaminants.

Freshness Evaluation: Assess the freshness of fish before purchase or consumption by checking for signs of spoilage, such as odor, texture, and appearance.

Prompt Consumption or Freezing: Consume fish as soon as possible after purchase. If not consumed immediately, freeze fish at temperatures below 0°F (-18°C) to preserve its quality. Freezing halts microbial growth and enzymatic activity.

11.7. Preservation and storage

Refrigeration: Refrigeration is a commonly used method to preserve fish. It involves storing fish at temperatures between 0°C and 4°C (32°F to 39°F). Refrigeration slows down microbial growth and enzymatic reactions by creating unfavorable conditions for spoilage bacteria. Low temperatures inhibit the growth of microorganisms, thereby delaying the onset of fish spoilage and extending its shelf life. However, refrigeration is not a long-term preservation method and is best suited for short-term storage.

Freezing: Freezing is a highly effective preservation method for fish. It involves lowering the temperature of fish below its freezing point (-18°C or 0°F) to halt microbial growth, enzymatic activity, and chemical reactions. Freezing forms ice crystals that immobilize microorganisms, preventing their growth and spoilage of the fish. Proper freezing techniques and packaging, such as using airtight containers or vacuum sealing, help prevent freezer burn and maintain the quality of frozen fish. Frozen fish can be stored for extended periods and retains its nutritional value and texture.

Canning: Canning is a preservation method that involves sealing fish in airtight containers and subjecting them to high temperatures. The heat treatment destroys microorganisms and inactivates enzymes, ensuring long-term preservation. Canned fish has an extended shelf life and can be stored at room temperature, making it convenient for storage and distribution. The hermetic seal of the can prevents the entry of oxygen and microorganisms, further preserving the fish. Canned fish retains its flavor, texture, and nutritional value.

Drying: Drying, or dehydration, is a preservation method that involves removing moisture from fish to inhibit microbial growth. Various techniques, such as sun drying, air drying, or using specialized drying equipment, can be employed. Removing moisture restricts the activity of spoilage-causing microorganisms, enzymes, and oxidation reactions. Dried fish has a longer shelf life and can be stored at ambient temperatures. However, the drying process may affect the texture and flavor of the fish. Rehydration of dried fish is necessary before consumption in many cases.

Smoking: Smoking is a preservation method that combines the effects of drying, heat, and smoke to preserve fish. It involves exposing fish to smoke generated by burning wood or other aromatic materials. The smoke acts as a preservative by inhibiting microbial growth and imparting characteristic flavors to the fish. The combination of heat and smoke helps in reducing moisture content and enhancing the keeping quality of fish. Smoked fish has a distinct smoky flavor and prolonged shelf life. However, it should be noted that smoking alone may not completely eliminate all microorganisms, so proper smoking techniques and hygienic practices are essential.

Salting: Salting, or curing, is a preservation method that involves applying salt to fish. Salt draws out moisture from the fish through osmosis, creating an inhospitable environment for microorganisms. The reduced water activity inhibits the growth of spoilage bacteria, thereby extending the shelf life of the fish. Cured fish has a firm texture, concentrated flavor, and extended shelf life. However, high salt concentrations can affect the taste and require desalting or soaking before consumption.

Fermentation: Fermentation is a preservation method that involves the controlled microbial breakdown of fish tissues. Beneficial microorganisms, such as lactic acid bacteria, ferment the fish, producing organic acids and other antimicrobial compounds. These compounds inhibit the growth of spoilage bacteria, extending the shelf life of the fish. Fermented fish products, such as fish sauce or fish paste, have a distinct flavor profile and an extended shelf life. Fermentation alters the taste, texture, and aroma.

Storage of fish refers to the proper handling, preservation, and maintenance of fish under specific conditions to ensure its safety, quality, and shelf life. Here are some key considerations for storing fish:

> **Temperature Control:** Temperature is a critical factor in fish storage. Most fish are highly perishable and should be stored at low temperatures to slow down microbial growth and enzymatic reactions. The recommended temperature range for fish storage is typically between 0°C and 4°C (32°F

to 39°F). This temperature range inhibits the growth of spoilage bacteria and helps maintain the freshness and quality of the fish.

Hygiene and Sanitation: Good hygiene practices are essential during fish storage. This includes cleaning and sanitizing storage areas, containers, and equipment to prevent cross-contamination and the growth of harmful bacteria. Proper personal hygiene should also be observed to avoid introducing contaminants to the fish.

Packaging and Wrapping: Packaging plays a crucial role in fish storage. It helps protect the fish from physical damage, moisture loss, and contamination. Airtight packaging, such as vacuum-sealed bags or moisture-resistant films, helps maintain the freshness of the fish and prevents the entry of air, which can accelerate oxidation and spoilage. Proper wrapping techniques ensure that the fish is tightly sealed to minimize exposure to air and prevent the growth of spoilage-causing microorganisms.

Storage Time: The length of time fish can be stored depends on various factors, including the type of fish, freshness at the time of storage, and storage conditions. Fresh fish should ideally be consumed within a few days of purchase. However, proper handling and refrigeration can extend the shelf life. It is important to check the quality of the fish regularly and discard any that show signs of spoilage.

11.8. Fish product

- **Fish Fillets:** Fish fillets are boneless cuts of fish that offer a versatile option for cooking. They are obtained by removing the bones and skin from the fish. Fish fillets are popular due to their ease of preparation and ability to absorb flavors during cooking. They can be grilled, baked, pan-fried, or deep-fried to create a variety of dishes. Fish fillets are widely consumed and appreciated for their tender texture and mild flavor.
- **Fish Steaks:** Fish steaks are thick, cross-sectional slices of fish that include the bone. They are obtained by cutting across the body of the fish. The bone-in structure of fish steaks contributes to their firmness and helps

retain moisture and flavor during cooking. Fish steaks are suitable for grilling, pan-searing, or baking. They are commonly used for species such as tuna, swordfish, and salmon. The meaty texture of fish steaks makes them a popular choice for those who prefer heartier seafood options..

- **Fish Fingers:** Fish fingers, also known as fish sticks, are pre-cooked and breaded pieces of fish that are typically frozen. They are a popular option for quick and easy meals, especially for children. Fish fingers are made from white fish varieties such as cod, haddock, or pollock. They are typically baked or fried until crispy. Fish fingers offer a convenient way to incorporate fish into meals and are often served with dipping sauces.
- **Canned Fish:** Canned fish products are a convenient and long-lasting option for enjoying fish. Common examples include canned tuna, canned salmon, and sardines. Fish is typically preserved in cans with oil, water, or sauces. Canned fish retains its nutritional value and can be easily incorporated into various dishes. It is used in sandwiches, salads, pasta dishes, or enjoyed directly as a protein-rich snack. Canned fish provides a shelf-stable option for those who may not have access to fresh fish regularly.
- **Fish Roe:** Fish roe, or fish eggs, is considered a delicacy in many cuisines. Different types of fish roe include salmon roe (ikura), cod roe (mentaiko), and sturgeon roe (caviar). Fish roe has a distinct flavor and texture, varying from creamy to briny. It is often used as a garnish, sushi topping, or incorporated into sauces and spreads. Fish roe adds a pop of color and unique taste to dishes.
- **Smoked Fish:** Smoking is a preservation method that imparts a smoky flavor to fish. Smoked fish products, such as smoked salmon, smoked trout, or smoked mackerel, are popular for their distinctive taste and aroma. The smoking process involves exposing fish to smoke generated by burning wood or other aromatic materials. Smoked fish can be enjoyed as a standalone item, used in salads, pasta dishes, or incorporated into spreads

and dips. The smoky flavor enhances the natural taste of the fish, creating a unique culinary experience.

These fish products offer a wide range of culinary possibilities, catering to different tastes and preferences. They provide options for those seeking convenience, unique flavors, and diverse cooking methods while incorporating the nutritional benefits of fish into their diet.

11.9. Let us sum up

Fish is a highly nutritious food source containing protein, lipids (fats), vitamins, minerals, and water. The composition can vary depending on the species, but fish generally provides high-quality protein, essential omega-3 fatty acids, vitamins (such as vitamin D and B vitamins), and minerals (such as calcium, iron, and zinc). It is low in saturated fat and a good source of unsaturated fats. Fish consumption is associated with numerous health benefits, including cardiovascular health, brain function, and overall well-being. When selecting fish, consider factors such as freshness, appearance, odor, and texture. Fresh fish should have clear eyes, bright red gills, moist skin, and a mild sea-like odor. The flesh should be firm and resilient to touch. It is important to choose fish from reputable sources and ensure it has been handled and stored properly.

Fish is highly perishable and can spoil quickly if not handled and stored correctly. Common signs of fish spoilage include off-putting odor, sliminess, discoloration, and changes in texture. Spoilage can be caused by bacterial growth, enzymatic reactions, and oxidation. Proper handling, refrigeration, and prompt consumption are essential to prevent spoilage. Various preservation methods are used to extend the shelf life of fish. These methods include chilling, freezing, canning, smoking, and drying. Chilling and freezing slow down bacterial growth and enzymatic reactions. Canning provides long-term shelf stability. Smoking and drying reduce moisture content and inhibit microbial growth. Each preservation method has specific requirements and benefits, and the choice depends on the desired outcome and storage conditions.

Proper storage conditions are crucial to maintaining the quality and safety of fish. Fish should be stored at low temperatures between 0°C and 4°C (32°F to 39°F) to slow down microbial growth. Hygiene and sanitation practices should be observed, and fish should be stored in clean, well-ventilated areas or appropriate containers. Regular monitoring of stored fish is necessary to check for signs of spoilage and ensure its freshness.

11.10. Glossary

Aquaculture: The farming of fish and other aquatic organisms in controlled environments.

Bivalve: A type of shellfish with a hinged shell, such as clams, mussels, or oysters.

Ceviche: A dish made by marinating raw fish or seafood in citrus juice, which "cooks" the fish through acid denaturation.

Fillet: A boneless piece of fish or seafood that has been cut or removed from the main body.

Fishery: An area where fish are caught or harvested commercially.

Fish meal: A protein-rich powder made by grinding dried fish, used as an ingredient in animal feed or aquaculture.

Fish oil: Oil extracted from fish, typically rich in omega-3 fatty acids, often used as a dietary supplement.

Fish stock: A flavorful liquid made by simmering fish bones, heads, and trimmings with vegetables and seasonings, used as a base for soups, sauces, and stews.

Freezing point depression: The lowering of the freezing point of fish and seafood due to the presence of water and other solutes, which helps preserve them when frozen.

Gelatin: A protein derived from fish collagen, used as a gelling agent in various food products.

Lox: A type of cured salmon, traditionally made by brining or smoking.

Sashimi: Thinly sliced raw fish or seafood, often served as a delicacy in Japanese cuisine.

Smoking: The process of exposing fish or seafood to smoke from burning wood or other materials, often used as a preservation method and to add flavor.

Surimi: A paste made from finely ground fish flesh, often used as a base for imitation crab and other seafood products.

Sushi: A Japanese dish consisting of vinegared rice combined with various ingredients, including raw fish or seafood.

Thawing: The process of defrosting frozen fish or seafood to prepare it for cooking or consumption.

11.11. Check your progress

Exercise 1

1. Fatty fish, such as salmon, tuna, and sardines, are known for their high …………………… content
2. Carbohydrates in fish are primarily found in the form of …………………, a storage form of glucose.
3. Oily fish, such as salmon and mackerel, are known for their high levels of …………………….. and ……………………………..
4. Fish proteins are particularly rich in essential amino acids like ……………, ………………, ……………….., and ……………...
5. Fish typically have a high water content, ranging from ……………………depending on the species, freshness, and habitat.

1. Briefly explain the nutritional value of fish.

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2. Discuss the Classification of fish.

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3. Explain the points that should be considered while selecting fish.

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4. State the changes that occur in fish during cooking.

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5. Define the following terms:

i. Canning

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ii. Freezing

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Smoking

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Fermentation

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6. Describe the factors that are responsible for fish spoilage.

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11.12. Answer key

Fill in the blanks:

1. Vitamin D
2. Glycogen
3. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).
4. Lysine, methionine, tryptophan, and leucine.
5. 65% to 85%

UNIT 12: PULSES AND LEGUMES STRUCTURE COMPOSITION AND PROCESSING

12.1. Introduction

In the previous unit we learnt about the egg, meat, poultry and fish. In this unit, we will learn about the composition and structure of pulses. It is a nutritious food with high protein content, essential fatty acids, vitamins, and minerals. We will discussed the Digestibility of pulses, Processing, Storage and infestation. Lastly we will study about the various anti-nutritional factors such as Trypsin inhibitor, Lathryogen, Favism, Haemagglutinin, Cyanogenic glycoside, Saponin, Goitrogen, Tanins etc.

Objectives

You will be able to:

- Learn about the composition and structure of pulses.
- Comprehend the Digestibility of pulses, Processing, Storage and infestation.
- Learn about the pulses cookery and its effect.
- Understand about the toxic constituent and anti-nutritional factor.

Pulses and legumes are a group of plants that belong to the family Fabaceae (also known as Leguminosae). This family includes a wide range of plants, including trees, shrubs, and herbs, that are commonly grown for food, animal feed, and as a source of fiber and fuel. Pulses are the dried seeds of legumes, including lentils, chickpeas, kidney beans, and peas. These crops are high in protein, fiber, and other essential nutrients, making them an important source of nutrition for people around the world.

Legumes, on the other hand, include a wider range of plants, including those that are grown for their edible pods or leaves, such as green beans and alfalfa. Other legumes are grown as forage for livestock, such as clover and soybeans. The production of pulses and legumes is widespread throughout the world, with many countries producing significant quantities of these crops. India is the world's largest producer of pulses, followed by Canada and Myanmar. Other major producers include Brazil, China, Ethiopia, and the United States.

India is the world's largest producer, consumer, and importer of pulses. Pulses are an important part of the Indian diet, and they are a source of protein for millions of people across the country. India produces a wide range of pulses, including lentils, chickpeas, pigeon peas, mung beans, and black-eyed peas. These crops are grown in various regions of the country, with different crops being suited to different agro-climatic zones. The major pulse-producing states in India are Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, and Andhra Pradesh. Other states like Gujarat, Karnataka, Punjab, Haryana, and Tamil Nadu are also significant producers. Pulses are mainly grown during the kharif (summer) and rabi (winter) seasons in India, with the major crop being harvested from September to November. However, some varieties like lentils and peas are also grown during the summer season.

India's pulse production has been affected by various factors, including erratic weather conditions, pest attacks, and soil degradation. To address these challenges, the Indian government has implemented various programs and initiatives to promote the production and consumption of pulses. These include subsidies for seed and fertilizer, the establishment of seed banks, and the distribution of high-yielding varieties of pulse seeds to farmers

Pulses and legumes are generally grown in a range of environments, from tropical to temperate regions. They are often used as rotation crops to improve soil health, as they have the ability to fix nitrogen from the air, which can help to reduce the need for chemical fertilizers. Overall, pulses and legumes are an important source of food and income for millions of people around the world, and their production and consumption are likely to remain an important aspect of global agriculture for many years to come.

12.2. Structure

Legumes are known for their unique structure, which includes a pod or fruit that develops from a flower. The pod contains one or more seeds, which are often referred to as pulses. The structure of pulses can be divided into three main parts: the seed coat, the cotyledons, and the embryo axis.

1. **Seed coat:** The seed coat is the outermost layer of the pulse and is made up of a tough, fibrous material that is designed to protect the seed from damage and dehydration. The thickness and texture of the seed coat can vary depending on the type of pulse. For example, chickpeas have a thicker seed coat than lentils, which makes them more resistant to damage and easier to store.

2. **Cotyledons:** The cotyledons are the two halves of the seed that are separated by a thin layer called the hilum. The cotyledons are the edible part of the pulse and contain most of the nutrients, including protein, carbohydrates, fiber, vitamins, and minerals. The cotyledons are connected to the embryo axis, which is a small structure at the base of the seed that contains the embryo.
3. **Embryo axis:** The embryo axis is the small structure at the base of the seed that contains the embryonic plant. The embryonic plant is the part of the seed that will grow into a new plant when conditions are favorable. The embryo axis is composed of several different parts, including the radicle, which will grow into the root of the plant, and the plumule, which will grow into the stem and leaves of the plant.

The structure of pulses is designed to protect the seed from damage and provide it with the nutrients and energy necessary for germination and growth. The cotyledons are the most important part of the pulse from a nutritional standpoint, as they are the source of most of the protein, carbohydrates, and fiber.

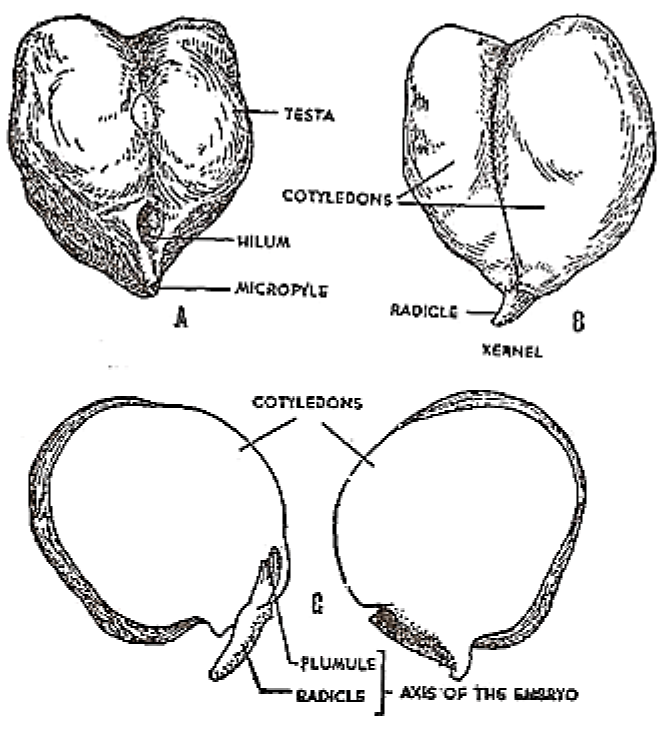

Figure 1: Structure of pulses

Source: Kulasinghe, Amali. (2019). Importance of Compositional Analysis of Traditional Agro-biodiverse Pulse Species Grown in Sri Lanka.

12.3. Composition

Pulses and legumes are highly nutritious foods that are rich in a variety of important nutrients, including protein, carbohydrates, fiber, vitamins, and minerals. The exact composition of pulses and legumes can vary depending on the type of pulse, as well as factors like growing conditions, harvesting methods, and processing techniques. However, here is a general overview of the composition of pulses and legumes:

Protein: Pulses and legumes are an excellent source of plant-based protein. The protein in pulses and legumes is considered to be high-quality because it contains all of the essential amino acids that the body needs to build and repair tissues. The protein content of pulses and legumes varies depending on the type of pulse or legume, as well as factors such as the variety of the plant, growing conditions, and processing methods. For example, lentils and chickpeas are known for their high protein content, with around 25-30% of their weight being protein, which makes them a popular food source for vegetarians and vegans. Other pulses, such as peas, beans, and soybeans, have slightly lower protein content, but are still a good source of this important nutrient.

Lentils and chickpeas are known for their high protein content, with around 20-25% of their weight being protein. Soybeans have the highest protein content of all pulses and legumes, with around 36% of their weight being protein. In general, pulses are relatively low in methionine and cysteine, two sulfur-containing amino acids. However, this can be compensated by consuming grains, nuts, and seeds, which are rich in these amino acids, in combination with pulses. This is because grains are lower in certain amino acids that pulses and legumes are high in, and vice versa. When combined, the two foods complement each other and provide a complete protein source. For example, in Indian cuisine, rice and lentils are often combined to make a dish called dal khichdi, which is a complete protein source.

Similarly, beans and corn are often combined in traditional Mexican cuisine to make a complete protein source.

Carbohydrates: The carbohydrates in pulses and legumes are mostly in the form of starch, which is a complex carbohydrate that is broken down slowly by the body. This means that pulses and legumes can provide sustained energy over a longer period of time compared to simple carbohydrates, such as those found in sugary snacks. Some pulses and legumes, such as soybeans, also contain small amounts of simple sugars like glucose and fructose. The amount of starch in pulses and legumes can vary depending on the type of pulse, the maturity of the seed, and the processing method. They are rich in both soluble and insoluble fiber, with some varieties containing up to 30% fiber.

The glycemic index (GI) of pulses and legumes is relatively low, which means they have a slow and steady effect on blood sugar levels. This is due to the presence of complex carbohydrates and fiber, which slow down the absorption of glucose into the bloodstream. As a result, pulses and legumes can help regulate blood sugar levels, making them a good food choice for people with diabetes or those at risk of developing diabetes.

Pulses and legumes are particularly high in unavailable sugars, which is why they are often associated with flatulence. Unavailable sugars, also known as oligosaccharides, are a type of carbohydrate that cannot be digested by the human body. These sugars are composed of short chains of sugar molecules, and include compounds such as raffinose and stachyose. Because the human body lacks the enzymes needed to break down these complex sugars, they pass through the digestive system undigested. Once they reach the large intestine, they are fermented by bacteria, which can produce gas as a byproduct. This gas can cause flatulence, bloating, and discomfort.

However, there are ways to reduce the levels of unavailable sugars in pulses and legumes. Soaking, sprouting, and cooking can all help break down and reduce the levels of oligosaccharides in pulses and legumes, making them easier to digest and reducing the risk of flatulence.

Lipid: The lipid content of pulses and legumes varies depending on the specific type. Generally, pulses and legumes are low in fat, with most varieties containing less than 2% fat. However, some varieties, such as soybeans, are higher in fat, with up to 20% of their weight being lipid.

Most of the lipids found in pulses and legumes are unsaturated, which means they are considered to be healthy fats. The predominant lipids in pulses and legumes are unsaturated fats, which are considered to be healthier than saturated fats. These unsaturated fats include linoleic acid, oleic acid, and alpha-linolenic acid, which have been linked to a range of health benefits, such as reducing inflammation, improving cardiovascular health, and aiding in the absorption of fat-soluble vitamins.

Vitamins: Pulses are a good source of several vitamins, including B-vitamins (thiamine, riboflavin, niacin, and folate), vitamin C, vitamin K, vitamin A, and vitamin E. The bioavailability of these vitamins can be influenced by factors such as processing, storage, and preparation methods. For example, cooking can increase the bioavailability of some vitamins but can destroy others, while soaking can reduce antinutrients and improve vitamin absorption. Storage conditions can also affect vitamin content, and fortification can be used to increase the nutritional value of some products.

Minerals:

Pulses and legumes are excellent sources of minerals, including iron, magnesium, phosphorus, potassium, and zinc. Pulses and legumes are a good source of magnesium, with some varieties, such as chickpeas and lentils, containing up to 15% of the daily recommended intake per serving. Navy beans and black-eyed peas, containing up to 20% of the daily recommended intake of Phosphorus per serving.

In pulses and legumes, phosphorus occurs in the form of inorganic phosphate salts, which are easily absorbed and utilized by the body. These phosphate salts are present in the form of phytic acid, also known as phytate, which is a storage form of phosphorus in plants. Phytate can bind to minerals such as calcium, iron, and zinc, which can reduce their bioavailability. The bioavailability of phosphorus in pulses and legumes can be affected by various factors such as the presence of other minerals, the form in which it is present, and the processing and preparation methods used. Soaking and cooking pulses and legumes can help to reduce the phytate content and increase the bioavailability of phosphorus and other minerals.

12.4. Digestibility of pulses

Pulses are generally considered to be a highly nutritious food source, but their digestibility can vary depending on several factors. Here is some information on the scientific basis of the digestibility of pulses and the factors that can affect it:

Antinutrients: Pulses contain various antinutrients, such as phytic acid, tannins, and trypsin inhibitors, which can interfere with the absorption of nutrients and reduce their digestibility. These antinutrients can be reduced by soaking, sprouting, and cooking pulses before consumption.

Fiber content: Pulses are high in dietary fiber, which can help to promote digestive health and prevent constipation. However, excessive intake of fiber can also cause digestive discomfort and bloating in some individuals, especially if they are not used to consuming high-fiber diets.

Protein content: Pulses are a rich source of plant-based protein, which can be less digestible than animal-based protein due to differences in amino acid profiles and the presence of antinutrients. However, research suggests that the digestibility of pulse protein can be improved by processing, such as heat treatment, fermentation, or enzymatic treatment.

Processing and preparation methods: The digestibility of pulses can be influenced by processing and preparation methods, such as soaking, cooking, and grinding. For example, soaking and cooking can help to reduce the antinutrient content of pulses and improve their digestibility.

Individual differences: The digestibility of pulses can also vary between individuals based on factors such as genetics, gut microbiota, and overall health status.

12.5. Processing

The processing of pulses and legumes can improve their nutritional value, reduce cooking time, and create a variety of products for consumption. It involve several steps, depending on the desired end product. Here are some common methods of processing:

12.5.1. Decortication

Decortication is the process of removing the outer layers of pulses and legumes, including the seed coat, husk, or bran, through mechanical or chemical means. The outer layers of pulses and legumes contain anti-nutrients such as phytic acid, trypsin inhibitors, and lectins that can interfere with nutrient absorption and digestion.

Mechanical decortication involves passing the pulses or legumes through a series of machines, such as hullers, dehullers, or milling machines, that separate the outer layers from the inner seed. The process typically involves applying pressure and friction to the pulses or legumes to break down the outer layers and separate them from the seed. Depending on the type of machine used, the process can be adjusted to remove different layers of the seed coat and produce various grades of decorticated product.

Chemical decortication involves treating the pulses or legumes with chemicals such as alkaline solutions, acids, or enzymes to break down the outer layers and remove anti-nutrients. This process is commonly used for beans, such as black beans or kidney beans, which have tough seed coats that are difficult to remove through mechanical means. The chemical treatment can be adjusted to control the degree of decortication and produce different grades of product.

It can improve the nutritional quality of pulses and legumes by reducing anti-nutrients and increasing nutrient bioavailability. For example, removing the seed coat of pulses can increase protein digestibility and mineral absorption, particularly iron and zinc. Decorticated pulses and legumes can also have improved cooking characteristics, such as reduced cooking time and improved texture.

12.5.2. Soaking:

Soaking is a common pre-cooking step for pulses and legumes that involves immersing them in water for a period of time before cooking. Soaking can improve the texture, digestibility, and nutrient content of pulses and legumes. During soaking, water is absorbed into the seeds, which can help to soften them and reduce cooking time. The water also helps to dissolve some of the water-soluble anti-nutrients, such as phytic acid and tannins that can interfere with nutrient absorption and digestion. Soaking can also activate enzymes that can improve the bioavailability of some nutrients, such as iron. The duration of soaking depends on the type and size of the pulse or legume. Generally, larger and harder pulses, such as chickpeas or kidney beans, require longer soaking times than smaller, softer legumes, such as lentils or split peas. Soaking times can range from a few hours to overnight, depending on the desired outcome.

12.5.3. Germination

Germination is the process of sprouting seeds, including pulses and legumes, under controlled conditions. It involves the activation of enzymes within the seed, which breaks down complex carbohydrates and proteins, and mobilizes stored nutrients, making them more available for absorption by the sprouting plant.

Germination of pulses and legumes can offer several advantages:

Improved Nutrient Absorption: During germination, the levels of anti-nutrients such as phytic acid, lectins, and enzyme inhibitors, which can bind to essential minerals and reduce their bioavailability, are reduced. As a result, germinated pulses and legumes have a higher bioavailability of essential minerals like iron, calcium, and zinc, and vitamins like vitamin C and vitamin B12. This can be particularly beneficial for populations at risk of micronutrient deficiencies.

Enhanced Digestibility: Germination can improve the digestibility of pulses and legumes, making them easier to digest and reducing gastrointestinal discomforts like bloating, flatulence, and constipation. The germination process breaks down complex carbohydrates like raffinose and stachyose, which are not digested by human enzymes, into simpler sugars like glucose and fructose, which can be easily absorbed by the body.

Increased Antioxidant Activity: Germination can increase the antioxidant activity of pulses and legumes by activating antioxidant enzymes like catalase and superoxide dismutase, and increasing the levels of phenolic compounds like flavonoids and phenolic acids. Antioxidants can scavenge free radicals and protect cells from oxidative damage, reducing the risk of chronic diseases like cancer, cardiovascular diseases, and neurodegenerative diseases.

Reduced Glycemic Index: Germination can lower the glycemic index of pulses and legumes, reducing the postprandial blood glucose response. The germination process breaks down starch into simple sugars, reducing the glycemic load, and increasing the fiber content, which can slow down the absorption of glucose in the bloodstream.

To germinate pulses and legumes, the seeds are first soaked in water for 8-12 hours, and then rinsed with fresh water to remove any debris or impurities. The seeds are then transferred to a sprouting jar, covered with a lid or cheesecloth to allow air to circulate, and placed in a cool, dark place. The seeds are rinsed with fresh water twice a day until sprouts appear, which usually takes 1-3 days depending on the type of seed and the ambient temperature.

12.5.4. Fermentation

Fermentation is a process that involves the breakdown of carbohydrates by microorganisms, typically bacteria or yeasts. Fermentation of pulses and legumes can offer several benefits, including improved digestibility, enhanced nutritional quality, and increased food safety.

During fermentation, microorganisms metabolize carbohydrates and produce organic acids, enzymes, and gases, which can modify the structure and composition of the food matrix. These changes can break down anti-nutrients like phytic acid, lectins, and tannins, making the nutrients in pulses and legumes more bioavailable for absorption by the body. Additionally, fermentation can increase the levels of beneficial bacteria like Lactobacillus and Bifidobacterium, which can improve gut health and boost the immune system. It can also enhance the flavor and aroma of pulses and legumes, adding complexity and depth to the food. Some examples of fermented pulses and legumes include tempeh, miso, natto, and fermented bean paste.

The fermentation process typically involves soaking the pulses or legumes in water for 8-12 hours, draining the water, and then inoculating the seeds with a starter culture, such as Rhizopus spores for tempeh or Bacillus subtilis for natto. The inoculated seeds are then incubated at a specific temperature and humidity for a certain period of time, depending on the type of fermentation and the desired end product. For instance, tempeh is typically fermented for 24-48 hours at 30-32°C, while natto is fermented for 18-24 hours at 40-45°C. During fermentation, the seeds are held in a container, which provides a controlled environment for the microorganisms to grow and metabolize the carbohydrates.

12.5.5. Parching

Parching is a traditional method of processing pulses and legumes that involves roasting the seeds in a dry heat, typically over an open flame or in an oven. Parching can improve the sensory properties of the pulses and legumes, such as their flavor, texture, and color, as well as increase their shelf life by reducing their moisture content.

During parching, the pulses or legumes are first cleaned and sorted to remove any foreign materials or damaged seeds. The seeds are then heated in a dry pan or oven until they are toasted and fragrant. Parching can be done with or without oil, depending on the desired end product and the type of seed being parched. The temperature and time required for parching can vary depending on the type of pulse or legume and the desired end product. For instance, parching of chickpeas may require a longer time and lower temperature than parching of lentils.

Parching can also improve the digestibility of pulses and legumes by breaking down some of the anti-nutrients, such as phytic acid, that can interfere with the absorption of nutrients like iron, zinc, and calcium. However, parching does not completely eliminate these anti-nutrients, so it is still important to combine parched pulses and legumes with a varied and balanced diet to ensure adequate nutrient intake.

12.5. Storage and infestation

Storage of pulses and legumes is an important aspect of their post-harvest management. Proper storage can prevent losses due to spoilage, insect infestation, and other factors, and can help maintain the quality and nutritional value of the seeds. When storing pulses and legumes, it is important to keep them in a cool, dry, and well-ventilated area to prevent the growth of fungi and bacteria. Moisture content is a critical factor in determining the storage life of pulses and legumes, and the seeds should be stored at a moisture level of 12% or lower. The storage area should also be free of pests, such as rodents and insects, which can damage the seeds and contaminate them with their feces and secretions. Infestation by pests is a common problem in the storage of pulses and legumes, and can cause significant damage to the seeds. The most common pests that infest stored pulses and legumes are beetles, weevils, and moths. These pests can lay eggs on the seeds, and the larvae can feed on the seeds, reducing their quality and nutritional value.

To prevent infestation, it is important to practice good sanitation in the storage area, including cleaning and disinfecting the storage bins and equipment. Proper packaging, such as storing the seeds in airtight containers or bags, can also help prevent infestation. Additionally, the use of natural pest control methods, such as diatomaceous earth or essential oils, can be effective in preventing and controlling infestations.

12.6. Toxic constituent

12.6.1. Trypsin inhibitor: Trypsin inhibitor is a class of anti-nutritional factors present in pulses and legumes that can interfere with the digestion and absorption of protein. Trypsin is an enzyme involved in the breakdown of dietary protein into smaller peptides and amino acids. Trypsin inhibitors bind to trypsin, preventing its activity and reducing the availability of protein for digestion. Trypsin inhibitors are found in varying amounts in different pulses and legumes, with soybeans being one of the richest sources. Other legumes such as kidney beans, lima beans, and navy beans also contain significant amounts of trypsin inhibitors.

The presence of trypsin inhibitors in pulses and legumes can have adverse effects on the nutritional quality of these foods. By interfering with protein digestion, trypsin inhibitors can reduce the availability of essential amino acids, which are required for growth and maintenance of body tissues. This can lead to poor growth, reduced protein utilization, and other nutritional deficiencies.

Processing methods such as soaking, germination, and cooking can reduce the levels of trypsin inhibitors in pulses and legumes, thus improving their nutritional quality. For instance, soaking pulses and legumes in water for several hours before cooking can reduce the levels of trypsin inhibitors by up to 90%. Germination can also reduce the levels of trypsin inhibitors, as well as increase the availability of other nutrients such as vitamins and minerals.

12.6.2. Lathryogen:

Lathyrogens are a class of anti-nutritional factors that are present in certain legumes, including grass pea (Lathyrus sativus) and some species of chickpeas (Cicer spp.). These compounds are known to cause a range of health issues, including neurolathyrism, which is a neurodegenerative disorder characterized by spastic paralysis of the lower limbs.

Lathyrogens are primarily found in the seeds of these legumes, and their levels can vary depending on the variety, growing conditions, and processing methods. The main lathyrogen in grass pea is beta-N-oxalyl-L-alpha-beta-diaminopropionic acid (β-ODAP), while in chickpeas, the lathyrogenic compound is believed to be a sulfonated aromatic amine called vicine.

Lathyrogens interfere with the synthesis and metabolism of collagen, a structural protein that is essential for the strength and integrity of tissues such as bones, skin, and cartilage. Ingestion of high levels of lathyrogens can lead to the accumulation of abnormal collagen in the body, resulting in the characteristic symptoms of neurolathyrism.

The disorder is characterized by a spastic paralysis of the lower limbs and can occur in stages.

The **first stage** of lathyrism is characterized by a feeling of weakness and stiffness in the legs, which can progress to difficulty in walking and standing. This stage typically lasts for a few weeks to a few months and is reversible if the intake of lathyrogens is stopped.

The **second stage** of lathyrism is marked by the development of spasticity, or increased muscle tone, in the lower limbs. This stage is irreversible and can lead to a permanent disability.

In severe cases, the disorder can progress to the **third stage**, which is characterized by the involvement of upper limbs and the neck. Symptoms include a loss of muscle control, difficulty in speaking and swallowing, and respiratory problems. This stage can lead to death in some cases.

The severity and progression of lathyrism depend on several factors, including the dose and duration of lathyrogen exposure, the age and nutritional status of the affected individual, and the presence of other medical conditions. Prevention of lathyrism primarily involves the avoidance of high-risk foods, particularly grass pea, and the consumption of alternative sources of protein. Certain varieties of grass pea with low levels of lathyrogens have been developed through breeding programs, and these are considered safe for consumption.

12.6.3. Favism

Favism is a condition caused by the ingestion of fava beans (Vicia faba) or other related legumes, which contain a class of compounds known as vicine and convicine. These compounds are metabolized in the body to produce a substance called divicine, which is toxic to red blood cells in certain individuals who lack the enzyme glucose-6-phosphate dehydrogenase (G6PD).

G6PD is an enzyme that plays a critical role in protecting red blood cells from oxidative damage. Deficiency of this enzyme can lead to hemolysis, or the breakdown of red blood cells, resulting in a range of symptoms, including fatigue, jaundice, dark urine, and abdominal pain. In severe cases, favism can cause acute hemolytic anemia, a life-threatening condition that requires immediate medical attention. The severity of favism depends on several factors, including the amount and frequency of fava bean consumption, the age and nutritional status of the affected individual, and the presence of other medical conditions. The condition is more common in males and individuals of Mediterranean, Middle Eastern, and African descent.

Prevention of favism involves the avoidance of fava beans and related legumes, particularly by individuals with known G6PD deficiency or those with a family history of the condition. In some cases, genetic testing may be recommended to identify individuals at risk of developing favism.

12.6.4. Haemagglutinins

Haemagglutinins are proteins found in some legumes, such as beans, peas, lentils, and soybeans. These proteins can cause red blood cells to stick together, which can interfere with the absorption of nutrients in the gut and cause damage to the gut lining.

However, there are ways to reduce the levels of haemagglutinins in legumes to make them safer to eat. Soaking and cooking can significantly reduce the levels of haemagglutinins in beans, while fermentation can do the same for soybeans. It's important to properly process and cook legumes to make sure they are safe to eat and provide the necessary nutrients.

12.6.5. Cyanogenic glycoside

Cyanogenic glycosides are natural compounds found in some plants, including certain types of pulses, such as cassava, lima beans, and chickpeas. These compounds can release toxic hydrogen cyanide gas when the plant material is crushed or chewed, or when it comes into contact with enzymes in the gut.

Consuming pulses that contain cyanogenic glycosides can be harmful to human health, causing symptoms such as headache, dizziness, nausea, vomiting, and even death in severe cases. However, the risk of cyanide poisoning can be reduced through proper processing and cooking methods.

Processing methods such as soaking, boiling, and fermentation can significantly reduce the levels of cyanogenic glycosides in pulses. For example, soaking and boiling cassava can reduce the levels of cyanogenic glycosides by up to 90%. Additionally, varieties of pulses with lower levels of cyanogenic glycosides can also be selected to reduce the risk of toxicity.

12.6.6. Saponin

Saponins are natural compounds found in various plant species, including some types of pulses such as chickpeas, lentils, and beans. These compounds have a bitter taste and are known for their ability to form a soapy foam when mixed with water. Saponins have been shown to have various biological effects, including antifungal, antimicrobial, and anti-inflammatory properties. However, they can also be toxic to humans and animals in large doses.

Consuming pulses that contain high levels of saponins can cause gastrointestinal distress, including diarrhea and vomiting. Moreover, saponins can interfere with the absorption of certain nutrients, such as proteins and minerals, which may lead to nutrient deficiencies. Fortunately, the levels of saponins in pulses can be reduced through various processing methods, such as soaking, boiling, and roasting. Proper processing can help to make pulses safe and nutritious to consume.

12.6.7. Goitrogen

Goitrogens are naturally occurring compounds found in various plant species, including some types of pulses such as soybeans, chickpeas, and lentils. These compounds interfere with the production of thyroid hormones, which are essential for normal growth and metabolism. Consuming pulses that contain high levels of goitrogens can lead to goiter, a condition characterized by an enlarged thyroid gland. In severe cases, goiter can cause hypothyroidism, a condition in which the thyroid gland fails to produce enough thyroid hormones.

However, the levels of goitrogens in pulses can be reduced through various processing methods, such as soaking, boiling, and fermentation. These methods help to break down the compounds responsible for the goitrogenic effect, making pulses safer to consume. Additionally, selecting varieties of pulses with lower levels of goitrogens can also reduce the risk of goiter.

It is important to note that goitrogens are not necessarily harmful to human health in moderation and can even have some beneficial effects. However, consuming large amounts of goitrogenic foods may increase the risk of goiter and hypothyroidism, particularly in individuals with pre-existing thyroid conditions

12.6.8. Tanins

Tannins are naturally occurring compounds found in various plant species, including some types of pulses such as chickpeas, lentils, and beans. These compounds have astringent properties and can bind to proteins and other molecules, making them difficult to digest. Consuming pulses that contain high levels of tannins can interfere with the absorption of certain nutrients, such as iron and zinc, leading to nutrient deficiencies. Additionally, tannins can irritate the digestive system, causing gastrointestinal distress, such as nausea and abdominal pain.

The levels of tannins in pulses can be reduced through various processing methods, such as soaking, boiling, and fermentation. These methods help to break down the compounds responsible for the astringent effect, making pulses safer and more nutritious to consume. Additionally, selecting varieties of pulses with lower levels of tannins can also reduce the risk of nutrient deficiencies and digestive issues

12.7. Pulse cooking

Pulses are often consumed after being cooked, but they require a longer cooking time than cereals. During the cooking process, the hard seed is softened by improving the flexibility of the cell wall, which makes it easier for the cells to expand and reduces their adhesion. Additionally, the cell cementing material known as pectin is change during cooking, leading to the separation of cells within the bean, thereby allowing for greater ease of consumption and digestion. Despite the fact that pulses require a longer cooking time than cereals, the cooking process is essential for making these nutritious legumes palatable and digestible.

12.7.1. Effect of pulse cooking

Cooking is an essential step in the preparation of pulses for consumption. Raw pulses are generally difficult to digest due to their high content of complex carbohydrates, fiber, and antinutrients. Therefore, cooking softens the seeds, breaks down the complex carbohydrates, and improves the palatability, making the pulses more easily digestible and enjoyable.

Improved digestibility:

Cooking of pulses improves their digestibility. During cooking, the high heat and moisture help to break down the complex carbohydrates and fiber that make pulses difficult to digest. The heat also helps to denature the protein present in the pulses, making it easier to digest. This results in a more easily digestible and absorbable food, with fewer digestive issues.

Enhanced nutritional value:

Cooking of pulses can also increase the availability of certain nutrients such as protein, vitamins, and minerals. When pulses are cooked, the heat breaks down the tough cell walls, releasing the nutrients present within. For example, cooking of legumes such as lentils, beans and peas can significantly increase the amount of bioavailable iron.

Reduced antinutrient content:

Antinutrients are compounds that can bind to nutrients in food, making them less available for absorption by the body. These compounds are present in many plant foods, including pulses. Some examples of antinutrients found in pulses include phytic acid, lectins, and tannins. Cooking of pulses can reduce the levels of these compounds, making more nutrients available for absorption.

Improved taste and texture:

Cooking pulses also improves their taste and texture. The heat softens the seeds, making them more tender and palatable. The flavors of spices and other ingredients used in cooking can also be absorbed by the pulses, resulting in a delicious and satisfying meal.

Increased shelf life:

Cooking and subsequent drying of pulses can also increase their shelf life by reducing moisture content and preventing spoilage. This is especially important in regions where pulses are a primary source of protein and are stored for extended periods

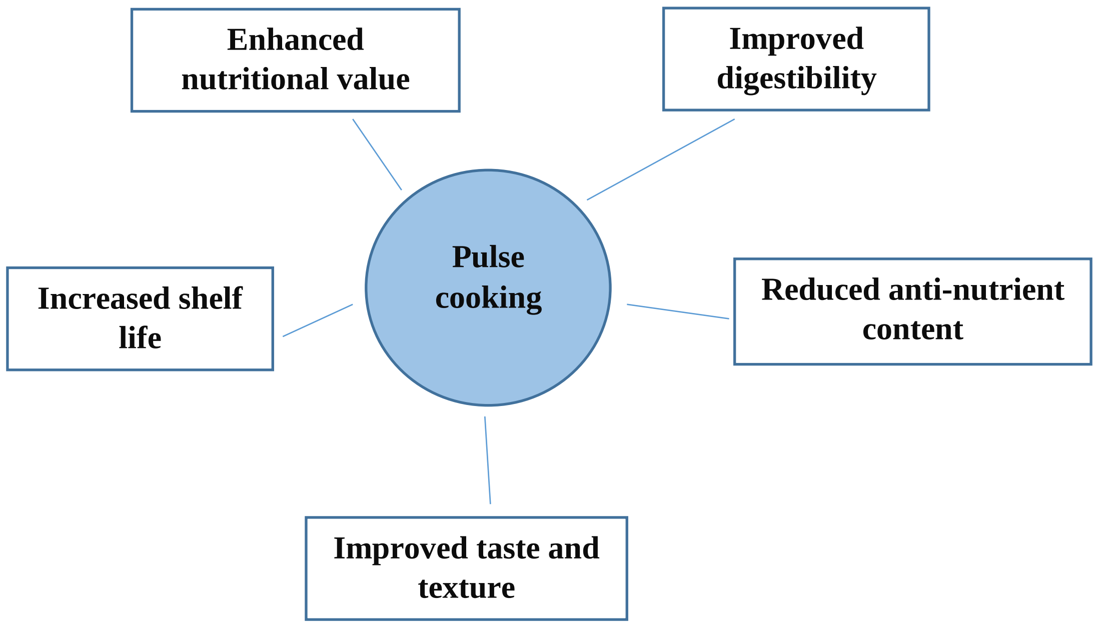

Figure 2: Effect of pulse cookery

12.8. Let us sum up

Pulses and legumes are a diverse group of plants that play a significant role in the human diet and global agriculture. Pulses refer to the edible seeds of legume plants, such as lentils, chickpeas, dry beans, and peas. Legumes, on the other hand, encompass a broader category of plants that includes pulses but also encompasses other legume species like soybeans and peanuts.

These nutrient-rich foods have been consumed for centuries and are valued for their high protein content, complex carbohydrates, fiber, and various vitamins and minerals. Pulses and legumes are particularly important for vegetarian and vegan diets, as they provide a plant-based source of protein and are low in fat. Their high fiber content promotes digestive health and helps regulate blood sugar levels.

From an agricultural perspective, pulses and legumes play a crucial role in sustainable farming practices. They have the unique ability to fix nitrogen in the soil, reducing the need for synthetic fertilizers and enhancing soil fertility. This property makes them valuable rotational crops, improving soil quality and reducing the risk of pests and diseases. Additionally, pulses and legumes are drought-tolerant crops, making them well-suited for arid and semi-arid regions.

The consumption of pulses and legumes has numerous health benefits. Regular intake can help prevent chronic diseases like heart disease, diabetes, and certain types of cancer. They also promote weight management and are associated with lower cholesterol levels. Furthermore, pulses and legumes have a low glycemic index, meaning they have a minimal impact on blood sugar levels.

The digestibility of pulses is influenced by several factors, including the presence of antinutrients, fiber and protein content, processing and preparation methods, and individual differences. Overall, consuming pulses as part of a balanced diet can provide a range of health benefits and is generally considered to be a healthy and nutritious food choice. Decortication is an important processing step for pulses and legumes that can enhance their nutritional value and improve their suitability for use in a variety of food products.

Soaking, fermentation and germination are simple and effective way to enhance the nutritional quality, digestibility, texture, and flavor, while also increasing their antioxidant activity and reducing their glycemic index.

Fermented pulses and legumes can be used in a variety of dishes, such as stir-fries, soups, salads, or as a meat substitute. Storage of pulses and legumes is essential to maintain their quality and nutritional value and prevent losses due to spoilage and infestation. A cool, dry, and well-ventilated storage area, low moisture content, and good sanitation practices can help prevent infestation by pests and other factors that can damage the seeds.

lathyrogens are a class of anti-nutritional factors found in certain legumes, including grass pea and some species of chickpeas. These compounds are known to cause a range of health issues, including neurolathyrism, and their levels in legumes are regulated in many countries. Favism is a condition caused by the ingestion of fava beans or related legumes by individuals with glucose-6-phosphate dehydrogenase deficiency. The condition is characterized by hemolysis, which can range from mild to severe and life-threatening. Prevention of favism involves the avoidance of fava beans and related legumes, particularly by individuals at risk of the condition. When preparing pulses for food, cooking is a necessary step. Due to their high content of complex carbs, fibre, and antinutrients, raw pulses are typically difficult to digest. Cooking makes pulses more palatable, digestible, and delightful by softening the seeds, reducing the amount of complex carbs present, and enhancing the flavour.

12.8. Glossary

Bioavailability: Bioavailability refers to the extent to which a nutrient or compound is absorbed and available for use by the body after ingestion or administration.

Decortication: Decortication is the removal of the outer layer or husk from grains, seeds, or legumes, typically done to improve the digestibility, nutritional profile, and culinary uses of the edible portion.

Glycemic Index: The glycemic index (GI) is a numerical scale that ranks carbohydrate-containing foods based on their impact on blood sugar levels compared to pure glucose.

Hemolysis: Hemolysis is the breakdown or destruction of red blood cells, leading to the release of hemoglobin into the bloodstream.

Lathryogen: Lathryogen is a neurotoxic compound found in the legume plant *Lathyrus sativus* (grass pea), and its consumption in high amounts over time can lead to a neurodegenerative disorder known as lathyrism, characterized by irreversible damage to the nervous system.

Oligosaccharides: Oligosaccharides are a type of carbohydrate composed of a few (2-10) sugar molecules linked together. They are commonly found in foods like legumes, onions, and garlic, and can be indigestible by human enzymes, leading to their fermentation in the gut and potential gas production.

Parching: Parching is a cooking method that involves subjecting grains, seeds, or nuts to dry heat, usually in a pan or oven, until they are lightly toasted or browned

Trypsin inhibitor: Trypsin inhibitors are natural compounds found in certain foods, particularly legumes that inhibit the activity of the digestive enzyme trypsin

12.10. Check your progress

Fill in the blanks

a) ……………………is the world's largest producer, consumer, and importer of pulses.

b) Pulses and legumes are a group of plants that belong to the family………………

c) Pulses and legumes are particularly high in unavailable sugars, which is why they are often associated with ………………….

d) ……………………..can bind to minerals such as calcium, iron, and zinc, which can reduce their bioavailability.

e) The cotyledons are the two halves of the seed that are separated by a thin layer called the …………………………..

f) chickpeas have a ……………..seed coat than lentils, which makes them more resistant to damage and easier to store.

g) Plant-based protein are less digestible than animal-based protein due to differences in amino acid profiles and the presence of …………………….

h) ……………………can help to reduce the antinutrient content of pulses and improve their digestibility.

i) ………………..pulses and legumes can also have improved cooking characteristics, such as reduced cooking time and improved texture.

j) ………………….is the process of sprouting seeds, including pulses and legumes, under controlled conditions.

k) Tempeh is typically fermented for …………. hours at 30-32°C.

l) ……………..interfere with the production of thyroid hormones, which are essential for normal growth and metabolism.

m) ……………………. is a neurodegenerative disorder characterized by spastic paralysis of the lower limbs

n) ……………..............is an enzyme that plays a critical role in protecting red blood cells from oxidative damage.

o) The main lathyrogen in grass pea is …………………………

p) Soaking pulses and legumes in water for several hours before cooking can reduce the levels of trypsin inhibitors by up to ………………

One word answer:

1. Name the anti-nutritional content present in pulses.
   …………………………………………………………………………………
   ……………………………………………………………………….
2. Name the process by which these anti-nutritional content can be removed.
   …………………………………………………………………………………
   ………………………………………………………………………
3. Name two unavailable sugar present in pulses.
   …………………………………………………………………………………
   ……………………………………………………………………….
4. State the prevention of favism
   …………………………………………………………………………………
   ………………………………………………………………………
5. Mention the symptom associated with consumption of pulses.
   …………………………………………………………………………………
   ……………………………………………………………………….
6. Name the pulses which contain saponins
   …………………………………………………………………………………
   ………………………………………………………………………

Short answer type question:

1. Briefly explain the structure of the pulses and legumes.
   …………………………………………………………………………………
   …………………………………………………………………………………
   …………………………………………………………………………………
   …………………………………………………………………………………
2. Discuss the composition of pulses and legumes.

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3. Briefly explain the factors affecting the digestibility of pulses.

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4. State the difference between Mechanical and Chemical decortication.

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5. Discuss the process of parching.

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6. State the advantages of fermentation.

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7. Briefly explain the structure of the pulses and legumes.

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8. Discuss about the different stages of lathyrism.

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9. Define the following terms:
    1. Tanins

    ………………………………………………………………………………

    ………………………………………………………………………………

    ……………………………………………………………………….……

    2. Haemaglutelins

    …………………………………………………………………………

    …………………………………………………………………………

    ………………………………………………………………….

1. Describe the importance of pulse cookery.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

…………………………………………………………………

12.11. Answer key

Exercise 1

a) India
b) Fabaceae
c) Flatulence
d) Phytate
e) Hilum
f) Thicker

g) Anti-nutrients
h) Soaking
i) Decorticated
j) Germination
k) 24-48 hours

Exercise 3

a) Goitrogens
b) lathyrism,
c) G6PD
d) beta-N-oxalyl-L-alpha-beta-diaminopropionic acid
e) 90%.

UNIT-13 NUTS AND OILSEEDS

Structure-

1.0 OBJECTIVES

After reading this unit, Students will able to-

- Know the Structure and Composition of Nuts and Oil Seeds
- Understanding the nutritive value of different Nuts and Oil Seeds
- Facilitate the information about Extraction Process for Nuts and Oil Seeds

1.1 INTRODUCTION- NUTS AND OIL SEEDS

Nuts are seeds or fruits that possess an edible, usually fat-containing kernel encased in a hard or broile shell. Nuts can be split into three food groups: those with a high fat or oil content, those with a high protein content, and those rich in carbohydrate, starches.

The majority of common dessert nuts are high in oil. This class of nuts includes cashewnuts, walnuts, pecans, and others. Groundnuts are an example of a high-protein nut. Protein-rich nuts also have a high fat content. Carbohydrates are found in only a few nuts. Chestnut, for example, is composed primarily of carbohydrates and is low in fats and proteins.

1.2 CLASSIFICATION OF NUTS AND OILSEEDS

Nuts are categorised into three types based on their composition. These are the classes:

1. Nuts having a high fat content, such as almonds, cashew nuts, and walnuts, which contain 50% or more fat.

2. Protein-rich nuts, such as groundnuts, which contain roughly 25% protein. Even almonds and pistachios have a protein content of roughly 20%. The majority of protein-rich nuts are also high in fat.

3. Carbohydrate-rich nuts, for example, chestnut has roughly 50% carbs but is low in proteins and lipids.

Nutritional Value

Aside from their delicious flavour, nuts are well-known for their high nutritional value:

- Nuts and oilseeds are high in fat and hence provide a concentrated source of calories. A handful of nuts can provide a lot of energy.

- They are also fantastic sources of high-quality protein. As a result, they are appropriate for all age groups, from youngsters to the elderly.
- To make them digestible, they should be thoroughly masticated and taken in tiny amounts.
- It is usually preferable to use powdered nuts for tiny children and the elderly.
- Nuts contain roughly 2% minerals, with a high phosphorus and potassium content.
- Some nuts also include calcium, salt, magnesium, and iron.
- They do not provide adequate carbs or roughage.
- The exception is chestnut, which contains around 50% carbohydrate.
- They have less than 5% water content. This is the only reason they can be stored for long periods of time.
- They are high in B vitamins, with groundnuts being particularly high in thiamine and nicotinic acid.
- Almonds, for example, are a good source of vitamin E.
- The majority of nuts, such as almonds, walnuts, and groundnuts, are consumed uncooked.

1.4 NUTRITIONAL COMPOSITION OF NUTS AND OIL SEEDS

Protein is abundant in oil seeds and nuts, particularly the amino acid arginine. Furthermore, they have a high fat content. As a result, they are not only high in protein but also a concentrated source of energy. Nuts are abundant in monounsaturated and polyunsaturated fatty acids and low in saturated fatty acids. Nuts with a desirable fat content and fatty acid composition can be included in cholesterol-lowering diets. They lower total and LDL (bad) cholesterol without changing HDL (good) cholesterol levels. Nuts are also high in omega-3 fatty acids.

Other vital nutrients found in them include manganese, copper, magnesium, phosphorus, and zinc. Most nuts, notably almonds, are high in vitamin E. The majority of the nuts are high in B vitamins, thiamine, riboflavin, and folic acid.

Groundnuts are a good source of niacin. Nuts are a nutritious snack that can be consumed in moderation. Ellagic acid, flavonoids, phenolic compounds, luteolin (a significant antioxidant), and tocotrienols are among the photochemicals found in nuts.

Food	**Energy (Kcal)**	**Protein (g)**	**Fat (g)**	**Carbohydrates (g)**	**Calcium (mg)**	**Iron (mg)**	**Carotene (mcg)**	**Thiamine (mg)**	**Ribo-flavin (mg)**	**Niacin (mg)**
Almond	655	20.8	58.9	10.5	230	5.1	0	0.24	0.57	4.4
Cashewnut	596	21.2	46.9	22.3	50	5.8	60	0.63	0.19	1.2
Coconut Dry	662	6.8	62.3	18.4	400	7.8	0	0.08	0.01	3.0
Coconut Fresh	444	4.5	41.6	13.0	10	1.7	0	0.05	0.10	0.8
Gardencress Seeds	454	25.3	24.5	33.0	377	100.0	27	0.59	0.61	14.3
Gingelly Seeds	563	18.3	43.3	25.0	1450	9.3	60	1.01	0.34	4.4
Groundnut	567	25.3	40.1	26.1	90	2.5	37	0.90	0.13	19.9
Mustard Seeds	541	20.0	39.7	23.8	490	7.9	162	0.65	0.26	4.0

Pistachio Nut	626	19.8	53.5	16.2	140	7.7	144	0.67	0.28	2.3
Soyabean*	432	43.2	19.5	20.9	240	10.4	426	0.73	0.39	3.2
Walnut	687	15.6	64.5	11.0	100	2.6	6	0.45	0.40	1.0

Source: Gopalan C et al. 1991

*Though it is a legume, since it yields substantial amount of oil, it is grouped under oilseeds.

1.3 SPECIFIC NUTS AND OIL SEEDS

Almonds:

Almonds are an extremely nutrient-dense food. They are a concentrated source of energy because they contain 60% fat. Almonds, like pulses, contain 20% protein. Carbohydrate content is modest, like with other nuts. They are a strong source of B vitamins and help to increase vitamin E content. Almonds include monounsaturated fatty acids, which lower the risk of heart disease by lowering LDL (bad) cholesterol.

Coconut:

Coconut water is a delightful and healthy drink. Coconut water has very little nutritional value. Although the white flesh is high in calories, it is low in protein. When dried, the white meat is known as khopra. It has a high oil content. After the oil has been removed, the leftover cake is fed to cattle.

Gardencress Seeds-

Gardencress seeds are high in protein, iron, and B vitamins. Women in India have traditionally ingested these seeds as a supplemental diet during the post-partum period. Iron and protein bioavailability is improved by processing.

Groundnut:

Peanuts, earthnuts, and monkey nuts are all names for ground nuts. They contain a lot of fat. The whole seed has roughly 40% fat, which is twice as much as soyabeans. They are extremely high in niacin. Methionine is absent from groundnut protein. Flavonol, an antioxidant, is abundant in groundnuts.

Groundnuts are eaten boiled or roasted. The main result, however, is the oil, which can be used as cooking oil or to make margarine. The residue or cake left over after the oil has been expressed is the secondary product. It is also refined and used as a supplement.

1. **Edible Groundnut Flour**:

The cleaned seeds are roasted at 80-900 degrees Celsius for 10 minutes before being abraded to remove the red skin. The decuticled seeds are expeller-pressed for oil and edible grade flour recovery. The protein-rich flour has been utilised to create nutritionally balanced dietary supplements such as Balahar, fortified wheat flour, and mass-feeding programmes.

2. **Protein Isolate**:

   Groundnut flour proteins are solubilized in an alkaline aqueous media, insoluble carbohydrates are separated by filtering or centrifugation, and proteins are precipitated at the isoelectric point. The protein isolate is bland, cream-colored, and contains more than 90% protein with a high nitrogen solubility index. Groundnut protein isolate is used in miltone, infant meals, biscuits, and confectionery, as well as coffee/tea whiteners.

   Deep green bottles have been determined to be superior to colourless bottles for oil storage based on peroxide value and acidity.

3. **Groundnut milk**:

   Impurities are eliminated from high-quality peanut kernels before they are lightly roasted and the red skin is removed. The kernels have been cleaned and mashed into a smooth paste. In a blender, combine the paste with 7 times the weight of water. The calcium hydroxide solution is added until the PH of the milk is 6.8. To stabilise the milk, a mixture of disodium phospate and acid potassium phosphate with a pH of 7.0 is added. The milk is filtered through a thin cloth and supplemented with vitamins A, D, B2, folic acid, B12, as well as minerals such as calcium and iron. Cane sugar is added at a rate of 7%. Soyabean or peanut milk can be used to complement the diets of pre-school and school-aged children. In the case of milk allergies, it can also be used as a substitute for regular milk.

4. **Peanut Butter-**

   After selecting and cleaning peanut kernels of high quality, they are roasted to a moderate temperature until a nice aroma develops. The roasted kernel is put through a blanching machine, which removes the red skin. The kernels are processed to a medium consistency in a grinding mill.

Hydrogenated fat with vitamin A is added at a level of 5 percent because it reduces the likelihood of oil separation. A 2% solution of sodium chloride is added. After being processed into a paste, the material is bottled. You can spread peanut butter on chapati, puri, or toast.

OILSEEDS:

India is one of the world's main producers of oilseeds. Groundnut and sesame are the most abundant crops in the country, followed by cottonseed, rapeseed-mustard, coconut, and soybean. It is predicted that the country's oilseed may produce up to 1.7 million tonnes of protein, which is more than what is currently accessible through animal products like as milk, eggs, meat, and fish. A variety of food products based on oilseeds have been developed to enhance people's diets, particularly those of youngsters.

Groundnuts, rapeseed-mustard, sesame, cottonseed, coconut, sunflower, soybean, niger, flaxseed, and other oilseeds are used for oil extraction. The amino acid methionine is deficient in the oilseed cake or meal, while it is abundant in the amino acid lysine. This cake is used to make multipurpose meals for many feeding programmes.

1.4 SIGNIFICANCE OF FATS AND OILS

1.4.1 Use of Fats in Food Preparation

- Meat, poultry, fish, dairy products, eggs, nuts, and oil seeds all contain naturally occurring fat, an unseen kind of fat.
- Natural food fats that can be seen include lard, olive oil, canola oil, peanut oil, and butter.
- A high melting point is what makes fats, which are solid at normal temperature, fats.
- Low melting point is what makes oils, which are liquids at room temperature, possible.

- Used as a taste enhancer, a cooking oil substitute, and a shortening when baking biscuits, cakes, and other foods.

1.4.2 <u>Nutritional Significance of Fats and Oils</u>

- Source of concentrated energy (9 kilocalories/1 gramme). Energy density is 2.25 times that of proteins and carbohydrates, respectively.
- Slim down by eating less food.
- Vitamins A, D, E, and K—which are fat-soluble—are abundant in these foods.
- Participate significantly in the biosynthesis of many long-chain fatty acids.
- Linoleic acid and other essential fatty acids (EFAs) are found in cell membranes.
- Used in the manufacture of prostaglandins, which have many important physiological roles including lowering blood clotting rates and preventing clot blockage in the coronary arteries.
- Poor gastric emptying and lancing slow down digestion. The effects of hunger will be postponed.
- Approximately 95% digestible.
- Melting point is a key factor in digestibility (M.P)
    - Melting point – < 430C – completely digested
    - Melting point – > 430C – slowly digested.

1.5 PRODUCTION AND PROCESSING METHODS FOR NUTS AND OIL SEEDS

1.5.1 <u>Raw Material Preparation</u>

Oilseeds and nuts need to be well washed and dried before being stored to prevent spoilage. Stones and moudly nuts should be removed from all raw materials throughout the sorting process. Aflatoxin is a poison produced by several moulds, particularly on groundnuts. If you must store something, do so in a place that is dry, well-ventilated, and secure from pests like birds and rats. Dehusking is a process that must be performed on some raw materials before they may be used (or decorticating). High oil yields and less processing time are also benefits of decortication. However, most expellers need a certain amount of fibrous material in order to function, and, in the case of groundnuts in particular, some husk is typically added to allow oil to escape from the press more easily. Professionals painstakingly dehusk and divide the coconuts. Grinding in mills increases oil production from most oilseeds (copra, palm kernels, and groundnuts). To get the most oil out of your oil bearing materials, make sure they have the ideal moisture level.

1.5.2 Oil Extraction Methods

A) Mechanical Expression

Mechanical expression entails subjecting the oil seeds to compression in a number of distinct compression apparatuses. The term "expression" refers to the mechanical process of extracting liquid from solids that contain liquid. There is a large variety of machinery used for liquid expression, including the screw press, roll presses, and collapsible plate.

i) Hydraulic Press: The horizontal corrugated iron plates that make up the hydraulic press are imagined to be interconnected. These discs have 4–14 preformed oil seed cakes in between them for insulation. There are two phases to the pressing process. The oil seeds are first pressed for 15–20 minutes at a pressure of 5 MPa, and then for further 5–10 minutes at a pressure of 28 MPa. Oil extraction rates varied widely based on seed size and type. However, screw-type presses are used in industrial settings while hydraulic presses are obsolete.

ii) Screw Press: The main shaft of a screw press is horizontal. This shaft incorporates the screw assembly in its entirety. The screw turns inside a cage or barrel. As the pressure on the feed material rises, oil drains out of the barrel, which is formed of case hardened, tool steel bars or rings. A moveable choke or cone at the discharge end regulates the working pressure. This is done by adjusting the diameter of the annular passage the oil cake travels through. A hand wheel at the other end of the screw controls the choke. Because of how the screw is set up, a far larger volume is displaced at the feed end of the press than at the discharge end. The material is subjected to rising pressure as it is transported from the feed end to the discharge end due to the design of the system. Oil is forced out via the gaps between the cage's inner bars as the material is crushed.

iii) Ram Press: A long lever is pivoted at one end, and it is used to reciprocate a piston housed in a cylindrical cage made of metal bars with gaps between them. The seed hopper feeds into the press cage via a port opened by the piston at one end of its stroke. The oilseed is squeezed inside the cage as the piston is pushed forward, closing off the entry post. When the oilseed breaks through the cage, the oil inside is released. The cage is used to force compressed seed through the openings. The compressed seed is forced through the circular opening at the cage's terminus.

1.5.3 <u>Oil Extraction</u>

The term "extraction" refers to any method that uses a solvent to remove a liquid from a solid system. Diffusion is also included in the extraction process, however this time a solvent with a low boiling point is used. In comparison to expression, this method results in a higher oil recovery and a dryer cake. Oilseed meal has a high oil content, although most of it can be extracted using a solvent. Meal extracted with this method has greater protein and greater stability.

Here, the solvent is added to the thoroughly ready substance. The next step in oil recovery is for a solvent-oil mixture to diffuse to the solid's surface. N-hexane, which has a boiling point of 65.5 degrees Celsius, is the most widely used solvent in India. Distillation and stripping under vacuum separate the oil from the oil and hexane miscella. In a de-solventizer, the extracted meal containing hexane is heated with live steam to remove the solvent. Deoiled cake is a type of dish that has a low percentage of oil in it (usually under 1%). Condensed solvent is recovered from the distillation column, stripping column, and de-solventizer, and placed in the solvent storage tank for later use. After being cooled, the is separated from the random stuff and placed in a storage tank.

Oilseed cake is processed in a solvent extraction factory, where hexane is used to remove the oil. These facilities are only viable for high-volume production due to the high initial investment required. When there is a surplus of oilseed cake, solvent extraction can be used to get rid of the last of the oil in the cake, leaving behind a dry powder called oilseed meal. Animal feeds often include both cake and meal.

1.5.4 Process of Oil Refining

Complexes of unrefined oils are favoured in many local markets, therefore further refining is unnecessary. Lighter, less potent cooking oils are preferred in international markets, necessitating additional refining of the oil. After the oil has been filtered, it can undergo a variety of refining operations.

i) **De-Odorising**

By sparging, i.e. bubbling steam through the oil under a vacuum, volatile chemicals that cause unpleasant odours can be eliminated.

ii) Wintering

Allowing the oil to rest at low temperatures for a period of time so that naturally occurring glycerides with higher melting points harden and can then be filtered out. Glycerides can deteriorate over time, releasing fatty acids into the oil and so increasing its acidity and decreasing its quality.

iii) Neutralisation

Fatty acids can be neutralised by adding a sodium hydroxide solution, often known as caustic soda, or by stripping, which is a deodorising process.

iv) Bleaching

Fatty acids can be neutralised by adding a sodium hydroxide solution, commonly referred to as caustic soda, or by stripping, a deodorising procedure. Some oils have an extremely dark colour that is disliked by customers. Bleaching can brighten the look of the oil.

v) De-Gumming

De-gumming is a treatment procedure for seeds with a high phosphatide content. By mixing the oil with 2% to 3% water, the phosphetide, which leaves a gelatinous residue, is removed. After that, the phosphatide can be removed by settling, filtration, or centrifugation.

1.6 TOXINS IN NUTS AND OILSEEDS :

Despite their numerous health benefits, nuts and oilseeds have certain drawbacks in the form of harmful elements contained in them or generated as a result of insufficient storage conditions. Some of them are as follows:

- Aflatoxin is a class of harmful fungal metabolites (mycotoxins) produced by specific moulds of the genus Aspergillus that grow on a variety of raw food commodities such as oilseeds, groundnuts, pistachios, brazilnuts, sunflower seeds, black pepper, figs, maize, and so on. The highest amounts are typically found in commodities from warmer regions of the world, where temperature, rainfall, and humidity vary greatly. At high enough levels of exposure, aflatoxins can induce acute toxicity and even death in animals and humans. The liver is the most severely afflicted organ, followed by the lungs, kidneys, brains, and hearts. Acute necrosis and cirrhosis of the liver are common, as are haemorrhage and oedema. Good agricultural practises are the most effective way to control aflatoxins before harvest. Toxin production can be reduced by treating with a fast lime-ammonia mixture. Around 100 nations have legislation limiting aflatoxins in food, and the majority of them contain maximum authorised or recommended levels for specific commodities.
- Lectins included in some nuts and seeds might irritate and inflame the stomach lining. Protein digestion can be slowed by enzyme inhibitors

found in them. As a result, patients with digestive and autoimmune issues should limit their intake of nuts and oilseeds.

- Phytic acid, found in nuts, binds minerals such as calcium, iron, and magnesium, preventing them from being absorbed. Cashews have 1866 mg of phytic acid per 100g, Hazelnuts 1620 mg, Almonds 1280 mg, Walnuts 760 mg, and Chestnuts 47 mg. Soaking nuts in salted water overnight removes the majority of the Phytic acid and other anti-nutrients. After soaking, nuts can be cleaned, dried in the sun or in a dehydrator, and stored for later use.
- If nuts are consumed in large quantities along with fructose (fruit sugar), a high amount of polyunsaturated fat (PUFA) can contribute to chronic and metabolic diseases such as diabetes, heart disease, and obesity. It is mostly eliminated during the refining process. Cotton seed varieties devoid of glands are immune to this toxin.
- Gossypol is another toxin produced by the pigment glands of cotton seed endosperm. It is mostly eliminated during the refining process. Cotton seed varieties devoid of glands are immune to this toxin.
-

1.6 LET US SUM UP

This section examined the various elements of Nuts and Oilseeds. The oil content of these nuts and oilseeds increases the availability of unsaturated fatty acids and necessary fatty acids in the daily diet. This unit describes the structure and nutritional profile of nuts and oilseeds. This section elaborates on the importance of nuts and oilseeds in food preparation and human health. The lesson contained a full overview of the processing of nuts and oilseeds, including pressing technique and solvent extraction. Therefore, this section contains thorough information regarding nuts and oilseeds.

1.7 KEYWORDS

Mechanical Expression	-----	During the mechanical expression procedure, the oil seeds are compressed using a variety of compression devices/equipment. Expression is the mechanical extraction of liquid from liquid-containing materials.
Bleaching	-----	Some oils have an extremely dark colour that consumers find unappealing. By bleaching, the look of the oil can be lightened.
Solvent Extraction	-----	Extraction is a process of separating a liquid from a solid system with the use of a solvent.
De-gumming	-----	De-gumming is a way of treating seed that have high phosphatide content.

CHECK YOUR PROGRESS EXERCISE

1- What do you understand by the term "Nuts and Oilseeds"?

………………………………………………………………………………
………………………………………………………………………………
………………………………

2- Write down a short note on "Nutritional Composition of Nuts and Oilseeds".

………………………………………………………………………………
………………………………………………………………………………
………………………………

3- Briefly explain about the significance of Nuts and Oilseeds.

…………………………………………………………………………………
…………………………………………………………………………………
………………………………

4- Write down about Processing Methods for Nuts and Oilseeds.

…………………………………………………………………………………
…………………………………………………………………………………
………………………………

Fill in the Blanks-

1. ………………………………..is a process of separating a liquid from a solid system with the use of a solvent.
2. The appearance of the oil can be lightened by the process of …………………………
3. Almonds are concentrated source of energy as they have ……………………..percent fat.
4. Volatile compounds that produce bad odours can eliminated through the process of sparging known as……………………..

State weather the statement is True or False-

1. Like pulses, oil seeds and nuts are rich in protein particularly the amino acid arginine.
2. Almonds are good source of monounsaturated fatty acids which increases the risk of heart disease.
3. The appearance of the oil can be lightened by De-gumming.
4. Gardencress seeds are excellent source of protein iron and B- vitamins.

Unit-14 FRUITS AND VEGETABLES

Structure-

1.0 OBJECTIVE

After reading this unit, Students will able to-

- Know the definition and concept of Fruits and Vegetables
- Explain Nutritional Composition of Fruits and Vegetables
- Describe about different Pigments, Flavour available in Fruits and Vegetables
- Discuss recent advancement in Preservation and Packaging of Fruits ad Vegetables

1.1- INTRODUCTION- FRUITS AND VEGETABLES

The term "fruit" in botany refers to the mature ovary of a plant, which includes the plant's seeds, covering, and any tissue that is intimately associated to it. It does not matter whether or not the seeds and covering are edible. As it relates to food, the term "fruit" in botany refers to the edible component of a plant that is comprised of the plant's seeds as well as the tissues that surround them. This category comprises both fleshy fruits (such as blueberries, cantaloupe, poach, pumpkin, and tomato) and dry fruits, in which the ripened ovary wall becomes papery, leathery, or woody, as is the case with cereal grains, pulses (mature beans and peas), and nuts. Fleshy fruits include blueberries, cantaloupe, poach, pumpkin, and tomato.

Vegetable is a botanical term that can be used to refer to any plant, regardless of whether or not it is edible. This includes trees, bushes, vines, and vascular plants. The term vegetable differentiates plant material from animal stuff and inorganic materials. In the context of food, the word "vegetable" can have two distinct botanical meanings, each of which is slightly distinct from the other. One definition states that a vegetable is a plant that is grown specifically for the purpose of harvesting its edible parts, while another defines vegetable as any part of a plant that can be consumed, including the stems and stalks (celery), root (carrot), tuber (potato), bulb (onion), leaves (spinach, lettuce), flower (globe artichoke), fruit (apple, cucumber, pumpkin, strawberries, tomato), or seeds (beans, peas). The second definition includes fruits inside the category of vegetables as a subset.

In other words, fruits can be defined as "edible parts of plants that contain the seeds and pulpy surrounding tissue; have a sweet or tart taste; generally consumed as breakfast beverages, breakfast and lunch side-dishes, snacks or desserts," while vegetables can be defined as "edible plant parts including stems and stalks, roots, tubers, bulbs, leaves, flowers and fruits; usually includes seaweed and sweet corn; may or may not include pulses or mushrooms; generally consumed as breakfast, lunch, snacks

1.2 CLASSIFICATION OF FRUITS AND VEGETABLES

1.2.1 Classification of Fruits-

The categorization of fruits can be done according to one of two criteria:

1. If the carpels that are present in the gynoecium are in a free state or if they are fused together.

2. The development of a fruit requires the contribution of at least one blossom.

Types of Fruits

1. Simple
2. Aggregate
3. Composite

1- Simple Fruit

These fruits originate from the multicarpellary syncarpous ovary or the monocarpellary ovary, depending on the type of ovary. The gynoecium can only produce a single fruit at a time. There are two categories of simple fruits:

• **Fruits with a Fleshing**: Epicarp, mesocarp, and endocarp are the three distinct layers that make up the wall of the fruit in fleshy fruits. These fruits originate from a syncarpous gynoecium that is either superior or inferior.

• **Dry Fruits**: In most cases, the pericarp of simple dry fruits is extremely dry and brittle. There is no clear demarcation between the three layers of epicarp, mesocarp, and endocarp in this structure. This pericarp is broken down in certain dried fruits, and this result in the seeds being scattered or distributed. These fruits have a hole in the middle of them.

In some fruits, the pericarp is further organised into one or more seeded segments. This occurs most commonly in berries and stone fruits. These kind of fruits are referred to as schizocarpic fruits. Even after the fruit has reached its full maturity or ripeness, the pericarp of some fruits does not appear to have dehisced. Such fruits are indehiscent Fruits.

2- Aggregate Fruits

These are the fruits that form as a result of the multicarpellary apocarpous ovary developing into fruit. In an apocarpous ovary, the process by which each carpel is differentiated from the others results in the formation of a fruitlet. The cluster of fruitlets that result from the ripening of these fruits is known as etaerio.

• **Etaerio of Follicles**: Each fruit, also known as an etaerio, is considered to be a follicle. Calotropis, Catharanthus, and Magnolia, to name a few examples. Calotropis is characterised by the stigma becoming fused or united in the carpellary ovary, while the ovaries of the ovules remain distinct. It indicates that there are just two follicles present in the etaerio.

• **Etaerio of Achenes**: Each individual fruit that makes up this aggregate fruit is an achene. Examples include the ranunculus, strawberry, rose, and lotus flowers. The thalamus of the lotus develops a sponge-like consistency, and several achenes are nested within it. The thalamus of a strawberry is fleshy, and the surface of the thalamus bears a number of tiny achenes.

• **Etaerio of Berries**: This refers to a collection of berries that are quite small. Eg. Polyalthia, Annona squamosa (Custard-apple). On the thalamus of the Annona etaerio, all of the berries are packed together in a thick arrangement.

• **Etaerio of Drupes**: This kind of fruit is characterised by the development of a great number of miniature drupes from a variety of carpels. For example, raspberry. The drupe fruit is formed by this sort of carpel of an apocarpous ovary.

3- Composite Fruits

All composite fruits are false fruits. In most cases, the formation of these fruits involves the cooperation of several ovaries and other floral organs and structures. These can be divided into two categories:

- **Sorosis**: The spike, spadix, or catkin inflorescence gives rise to these fruits. Examples include the Jackfruit fruit and the screwpine (Kevda). Around the peduncle of the jackfruit (Kathal), pistillate blooms will grow. During the process of fruit production, the pericarp will become united and spongy.

- **Sycosis**: These fruits develop from an inflorescence of hypanthodium. The receptacle develops a hole in its side and becomes hollow. The pore is surrounded by a plethora of minute scales. Example- Ficus species Peepal

Fruits can be further subdivided into the following categories, depending on an additional set of criteria based on their form, cellular structure, kind of seed, or natural habitat:

Berries	Strawberries, gooseberries, blackberries, raspberries, blueberries, cranberries.
Citrus fruits	Sweet limes, oranges, tangerines, sour oranges, lime, lemon, grape fruit.
Drupes	Plums, apricots, peaches, and sweet cherries make excellent prunes
Grapes	Green grapes, black grapes, seedless grapes.
Melons	Musk melon, water melon.
Pomes	Apples, pears.
Tropical and subtropical fruits	Amla, avocado, banana, dates, guava, Jack fruit, mango, jambu fruit, papaya, passion fruit, pineapple, pomegranate, sapota, seetaphal.

1.2.2 <u>Classification of Vegetables</u>-

Vegetables are categorised based on which portion of the plant is consumed. Some vegetables fall into more than one category because many portions of the plant are edible, such as beetroot, which may be eaten from both the roots and the leaves. Bulbs typically develop slightly beneath the ground's surface and produce a fleshy, leafy stalk above ground. Bulbs are often made up of layers or grouped pieces. fennel, garlic, leek, onion, shallot, spring onion, and so on

- Flowers- Edible blooms of various vegetables, such as artichoke (globe), broccoflower, cauliflower, broccoli, choi sum, courgette or other squash flowers, gai lan (Chinese sprouting broccoli), and others.
- Fruits: Bitter melon, capsicum, chilli, choko, courgette, cucumber, eggplant, fuzzy melon, Indian marrow, marrow, plantain, pumpkin and squash, scallopini, tindora, tomatillo, tomato, turia (ribbed gourd)
- Fungi-Fungi are often known as mushrooms when referring to vegetables, such as button white, Swiss brown, cup (opened not flat), enoki, oyster, Portabello (brown flat or cup), shiitake, and truffle - black and white.
- Leaves -Edible leaves of plants such as bok choy, Brussels sprouts, cabbage, lettuce, ong choi, puha, radicchio, silverbeet, sorrel, spinach, tat soi, tung ho, watercress, witloof, and wong nga baak (Peking cabbage).
- Seeds- (Legumes) Other than sweet corn, seeds grow in pods that are occasionally eaten with the seed, such as bean (green, French, butter, snake), broad bean, pea, snow pea and sweet corn.

Stems-Edible stalks of plants that are the main portion of the vegetable, such as asparagus, celery, and kohlrabi.

1.3 COMPOSITION OF FRUITS AND VEGETABLES

Nature's wonderful gift to humanity is vegetables and fruits. Vegetables and fruits are essential components of our everyday nutrition. They are anti-aging medications high in vitamins, minerals, antioxidants, and phytonutrients (plant-derived micronutrients). Vegetables and fruits are accessible all year and can be eaten both fresh and raw. They are a visual feast because of their colour, and they contain a unique vitamin profile that helps the human body stay fit, rejuvenated, and disease-free.

1.3.1 Composition of Fruits-

- Fruits are very low in protein and fat.
- Except for avocado, which contains 28% fat, fruits are poor providers of calories. Bananas, for example, have a high calorie content.
- Ripe fruit has a higher percentage of sugar than unripe fruit, and the sugar is primarily in the form of sucrose, fructose, and glucose.
- Fruits are generally low in iron. Seethaphal is also an excellent source of iron. Mangoes are a great source of carotenes. The Alphonso cultivar was discovered to be the most abundant source of - carotene. Banginapally and Peddarasalu are good sources of carotenoids. Apart from mango, Indian dates and papaya are high in -carotene. Oranges are a good source of beta-carotene.
- Guavas have the highest vitamin C content of any fruit. Citrus fruits are high in vitamin C as well. Cashew fruits are low in cost and high in vitamin C. Although vitamin content varies from fruit to fruit, most fruits in their uncooked state include some ascorbic acid. Amla is the most abundant source of vitamin C. Large levels of the vitamin may be oxidised when fruits are damaged, peeled, cooked, or exposed to air, alkali, or copper.
- Flavonoids, which work as antioxidants, are found in apples, pears, cherries, grapes, and citrus fruits.

1.3.2 Composition of Vegetables-

- Because of the high concentration of starch and other carbohydrates that are found in tubers and roots, such as carrots, potatoes, and sweet potatoes, these foods contribute to the overall energy value of the dish.
- Carrots are an excellent source of beta carotene, which is also known as vitamin A. Sweet potatoes and regular potatoes are both excellent sources of the vitamins B6 and C, as well as potassium and iron.

- Phosphorus, calcium, and iron are all found in high concentrations in green leafy vegetables. They have a high carotene content and are also a strong source of antioxidants (vitamin A).
- Greens are rich in vitamin B, notably riboflavin and folic acid, and are therefore a good source of these vitamins. Vitamin B is lost during the drying and withering processes.
- Agathi, drumstick leaves, and coriander leaves are examples of vegetables that are green and leafy, and they all contain vitamin C.
- Iron can be found in abundance in dark green leafy plants. Example- Mint leaves, drumstick leaves, paruppukeerai.
- Agathi leaves, colocasia leaves, drumstick leaves, and fenugreek leaves all contain calcium and should be included in your diet.
- Greens are rich in fibre, which plays a role in warding off degenerative illnesses and is hence beneficial.
- Both beans and peas have a high concentration of fibre.
- Beans, peas, and lentils are great sources of certain vitamins and minerals, such as folate, iron, potassium, and magnesium. Fibre contributes to an increase in the volume of faeces, which helps avoid constipation. Folate and iron are essential nutrients, not just for warding off anaemia but also for ensuring that metabolic processes continue to run normally. Potassium and magnesium are two minerals that play a significant role in the function of muscles and nerves.

1.4 NUTRITIVE VALUE OF FRUITS AND VEGETABLES

- A significant amount of water can be found in vegetables. In addition, they are rich in carbohydrate, dietary fibre, protein, vitamin, and other essential nutrients for human health.

- Since plants like lettuce, cucumbers, and other leafy greens contain approximately 95% water, just 5% of their mass is composed of dry matter. Rough vegetables like carrots and pumpkins have a dry matter content of approximately 12-15%.Carbohydrates make up more than 90 percent of the dry matter of vegetables and fruit, making them the primary component of these food groups. Starch, sugars, and dietary fibre are all forms of carbohydrates that can be found in food.
- Root vegetables, such as potatoes and sweet potatoes, are where starch is most commonly found in vegetables. Fructose, glucose, and sucrose are the primary forms of sugar that are found in vegetables and fruits, respectively. Despite the fact that they are more commonly associated with fruits, sugars are an essential part of the flavour profile of vegetables like carrots, sweet corn and peas.
- Vegetables and fruits include dietary fibre compounds such as cellulose, lignin, pectins, and other substances as well. Vegetables and fruits include dietary fibre, which has various positive health effects, including a reduction in both blood sugar and cholesterol levels.

NUTRITIVE VALUE OF FRUITS

Food	Moisture (g)	Energy(kcal)	Protein(g)	Fat(g)	Carbohydrates(g)	Calcium(mg)	Iron(mg)	Carotene(ug)	Ascorbic(mg)
Amla	81.8	58	0.5	0.1	13.7	50	1.2	9	600
Apple	84.6	59	0.2	0.5	13.4	10	0.6	0	1
Banana	70.1	116	1.2	0.3	27.2	17	0.4	78	70
Cashew fruit	86.3	51	0.2	0.1	12.3	10	0.2	23	180
Grapes blue	82.2	58	0.6	0.4	13.0	20	0.5	3	1
Grapes pale green	79.2	71	0.5	0.3	16.5	20	0.5	0	1
Guava	81.7	51	0.9	0.3	11.2	10	0.3	0	212
Jack fruit	76.2	88	1.9	0.1	19.8	20	0.6	175	7
Sweet lime	90.5	43	0.7	0.3	9.3	30	0.7	0	50

Mango ripe	81.0	74	0.6	0.4	16.9	14	1.3	2743	16
Melon musk	95.2	17	0.3	0.2	3.5	32	1.4	169	26
Melon water	95.8	16	0.2	0.2	3.3	11	7.9	0	1
Orange	87.6	48	0.7	0.2	10.9	26	0	1104	30
Papaya	90.8	32	0.6	0.1	7.2	17	0.5	666	57
Pineapple	87.8	46	0.4	0.1	10.8	20	2.4	18	39
Plum	86.9	52	0.7	0.5	11.1	10	0.6	166	5
Pomegranate	78.0	65	1.6	0.1	14.5	10	1.8	0	16
Sapota	73.7	98	0.7	1.1	21.4	28	1.3	97	6
Seethaphal	70.5	104	1.6	0.4	23.5	17	4.3	0	37
Tomato ripe	94.0	20	0.9	0.2	3.6	48	0.6	351	27

Source: Gopalan, C., Rama sastri B.V. and Balasubramanian S.C., 1991.

NUTRITIVE VALUE OF VEGETABLES

	Energy (Kcals)	Moisture (g)	Protein (g)	Fat (g)	Mineral (g)	Carbohydrates(g)	Fibre (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)
Ash gourd	10	96	0	0	0	2	1	30	20	1
Beans, scarlet	158	58	7	1	2	30	2	50	160	3
Bitter gourd	25	92	2	0	1	4	1	20	70	1
Bitter gourd, small	60	83	2	1	1	11	2	23	38	2
Bottle gourd	12	96	0	0	0	2	1	20	10	0
Brinjal	24	93	1	9	9	4	1	18	47	0
Broad beans	48	85	4	0	1	7	2	50	64	1
Cauliflower	30	91	3	0	1	4	1	33	57	1
Cho-cho marrow	27	92	1	0	0	6	1	140	30	1
Cluster beans	16	81	3	0	1	11	3	130	57	1
Colocasia stem	18	94	0	0	1	4	1	60	20	0
Cowpea pods	48	85	3	0	1	8	2	72	59	2
Cucumber	13	96	0	0	0	2	0	10	25	1
Double beans	85	74	8	0	1	12	4	40	140	3
drumstick	26	87	3	0	2	4	5	30	110	0
drumstick flowers	50	86	4	1	1	7	1	51	90	0
Field beans,	48	86	4	1	1	7	2	210	68	1

tender										
Figs, red	53	80	1	1	2	11	6	187	39	0
French beans	26	92	2	0	1	5	2	50	28	1
Ghosala	18	93	1	0	1	3	2	36	19	1
giant chillies	24	93	1	0	1	4	1	10	30	0
Jack fruit, tender	51	84	3	0	1	9	3	30	40	2
Jack fruit seeds	133	65	7	0	1	26	2	50	97	2
kankoda	52	84	3	1	1	8	3	33	42	5
Karonda fresh	42	91	1	3	0	3	2	21	28	0
Karonda dry	364	18	2	10	3	67	0	160	60	39
Kheksa	29	90	1	0	1	6	2	27	38	0
Kovai	18	93	1	0	1	3	2	40	30	0
Knol-Khol	21	93	1	0	1	4	2	20	35	2
Ladies finger	31	90	2	0	1	6	1	66	56	0
Lakuch, raw	73	90	2	1	1	14	3	67	25	0
Leeks	77	79	2	0	1	17	1	50	70	2
Lotus stem, dry	234	10	4	1	9	51	25	405	128	61
Mango, green	44	88	1	0	0	10	1	10	19	0
Onion stalks	41	88	1	0	1	9	2	50	50	7
papaya, green	27	92	1	0	1	6	1	28	40	1
Parwar	20	92	2	0	1	2	3	30	40	2

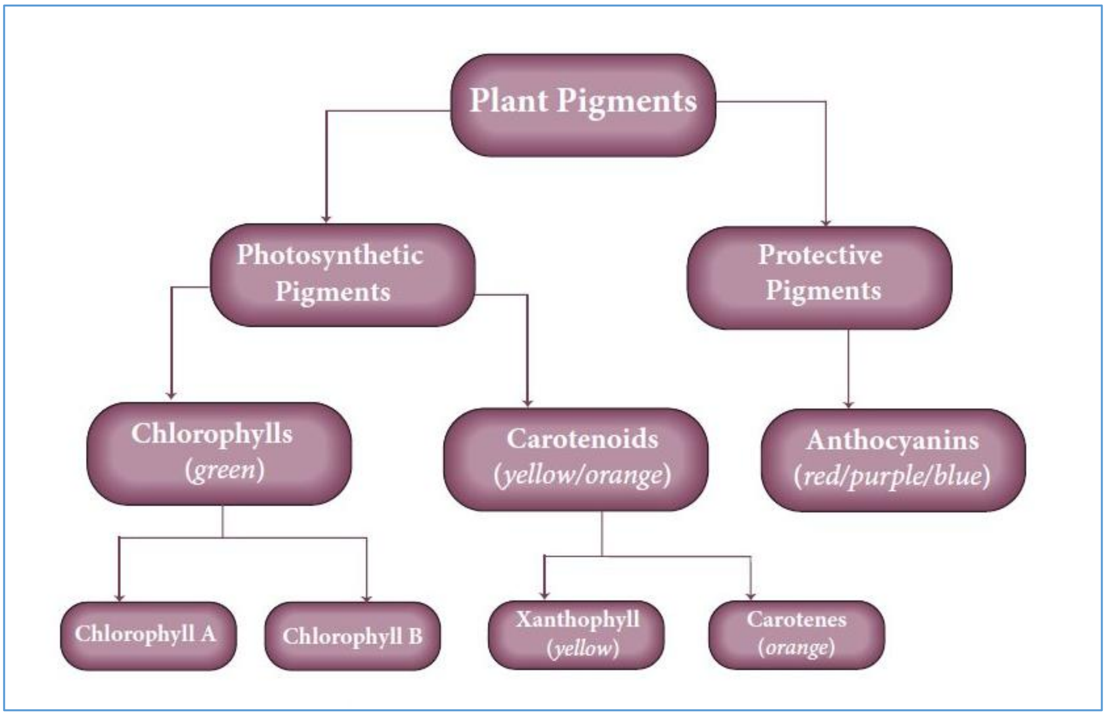
Pink beans	44	87	3	0	1	7	2	54	70	2
Plantain flower	34	90	2	1	1	5	1	32	42	2
Plantain green	64	83	1	0	1	14	1	10	29	6
Plantain stem	42	88	1	0	1	10	1	10	10	1
pumpkin fruit	25	93	1	0	1	5	1	10	30	0
pumpkin flowers	39	89	2	1	1	6	1	120	60	0
ridge gourd	17	95	1	0	0	3	0	18	26	2
Snake gourd	18	94	1	0	1	3	1	26	20	22
Sundakai, dry	269	12	8	2	5	55	18	390	180	2
Sword beans	44	87	3	0	1	8	2	60	40	2
Tinda, tender	21	93	1	0	1	3	1	25	24	1
Tomato, green	23	93	2	0	1	4	1	20	36	2
Vegetable marrow	17	94	1	0	0	3	1	10	30	1
Water chestnut, fresh	115	70	5	0	1	23	1	20	150	2
Water chestnut, dry	330	14	13	1	3	69	0	70	440	2

Source: Gopalan, C., Rama sastri B.V. and Balasubramanian S.C., 1991.

1.5 PIGMENTS IN FRUITS AND VEGETABLES

The pigments that are found in the plastids of plant cells are responsible for the vibrant colours that are found in vegetables and fruits. These colours are what attract people to eat vegetables and fruits. The primary pigments found in vegetables and fruits can be divided into two categories: those that are water soluble and those that are fat soluble.

Fat Soluble/Lipophilic Pigments	Water Soluble/Lipophobic Pigments
Chlorophyll-II	Anthocyanin (Red, Blue, Purple)
Carotenoids (Red, Orange and Yellow)	Flavones and Flavanols (Yellow) and Flavanals



Classification of Pigments in Fruits and Vegetables

Chlorophyll

Leafy vegetables and other green-colored vegetables, such as capsicum, beans, peas, and chillies, contain a component called chlorophyll, which gives these veggies their green colour. It dissolves very poorly in water if at all. It has been possible to separate two different cholorophylls. Cholorophyll-a has a hue that is described as a vibrant blue-green, whilst cholorophyll-b has a colour that is described as a muted yellow-green.

Carotenoids

The yellow, orange, and red pigments that are fat-soluble and can be found in nature are called carotenoids. They can be broken down into three different categories: carotenoids, which are found in carrots, green leafy vegetables, and other fruits; lycopenoids, which are found in tomatoes; and xanthophylls, which are found in yellow fruits.

Anthocyanin, anthoxanthin, leuco anthoxanthin, catechin, quinones, and betalins are all examples of pigments that include the phenolic group. The term "Flavanoids" refers to the aggregate name for the first four groupings.

Anthocyanin

They are a category of water-soluble pigments that have a reddish colour and can be found in a variety of fruits and vegetables. Anthocyanins are the pigments responsible for the vibrant colours of cherries, red apples, and pomegranates.

Anthoxanthins

They are odourless pigments that range in hue from white to yellow and are responsible for the coloration of cauliflower, onions, spinach, and other green vegetables. Chlorophyll, which gives green leafy vegetables their green tint, conceals the true colour of the food.

1.6 FLAVOUR CONSTITUENTS OF FRUITS AND VEGETABLES

Flavour Constituents

Esters, aldehydes, alcohols, ketones, and ethers are all examples of volatile flavour compounds. Ketones are another volatile flavour molecule. Some fruits have essential oils, which are not only key flavour contributors but also important flavour contributors.

Polyphenols: Catechins, leucoanthocyanins, and hydroxyl acids were the three components that made up tannins or polyphenols. Tannin can be found in high concentrations in the skin and the seeds. Tannins are extracted into the juice during the pressing of fruits like apples and grapes for the production of cider and wine, respectively. Tannins are found in both beverages.

Effects of Polyphenols on Fruit Quality

- Polyphenols are the culprits behind the unpleasant astringency that can be found in certain fruits, as well as the pleasant astringency that can be found in ciders and wines. The puckering sensation that occurs in the mouth as a result of the presence of certain substances, most notably flavanols, is referred to as astringency.
- The interaction of proteins and phenolic polymers is thought to be responsible for the creation of the unpleasant haze and precipitates that can be found in apple juice, beer, and wine.
- The oxidation of phenolic compounds (chlorogenic acids, catechins) by polyphenolase enzymes causes a brown discoloration to develop in cut fruits. This is the cause of the development of brown discoloration.
- The production of dark-colored complexes with iron as a result of the sequestering effect of the dihydric and trihydric phenolics, which causes canned foods to have an unattractive look.
- The presence of leucoanthocyanins has been shown to be responsible for the development of a pink to pinkish brown hue in fruits such as pears, guavas, apples, bananas, and litchi.
- As bananas ripen, the excessive concentrations of flavanols found in the unripe fruit are reduced, making ripe bananas a better source of health benefits. When peaches are allowed to ripen in conditions that are warm and clear, the fruit will have a lower polyphenol content than when it is allowed to ripen in conditions that are overcast. The lower polyphenolic content results in a less astringent finished product.

Bitterness in Fruits

- Bitterness in citrus fruits can be attributed to compounds of two classes, the limonoids (triterpenes) and the flavanone glycosides (flavonoids).

- The Precursor of Limonin is naturally present and stable in intact citrus tissue but when the fruit is squeezed to yield juice, the active compound of the precursor in combination with the acidic pH results in the formation of limonin.
- The principal flavonoid bitter tasting component of citrus fruit is the flavanone glycoside, naringin. It is the major flavonoid of grape fruit.
- Certain citrus products when heated can develop a bitter off flavour. The compound thought to be resoponsible is limonin which is intensely bitter tasting triterpenes dilactone which can also be naturally occurring in citrus products.

1.7 POST HARVEST CHANGES AND STORAGE OF FRUITS

After reaching full maturity, the fleshy tissues of fruits and vegetables will typically continue to develop and age while they are being stored. This process is known as senescence. Senescence is characterised by a rapid decline in palatability that happens simultaneously with the process. All fruits and vegetables engage in specific kinds of biochemical processes, such as respiration, protein synthesis, and changes in certain elements of cell walls. Among these processes are respiration, protein synthesis, and alterations.

In many fruits, the rate of respiration changes as the fruit progresses through its many stages of maturation and ripening, with the rate reaching its highest point shortly before it is completely ripe. The climacteric is the name given to this stage. The term "climacteric fruits" refers to those fruits that show an increase in their respiration rate immediately before entering their senescent stage. They are distinguishable from other fruits by the fact that after being picked when they are horticulturally mature but not yet ripe, they can still complete the ripening process and become fully ripe. Grapes and citrus fruits do not go through the climacteric stage. Following harvesting, there is no increase in the pace at which they breathe. When allowed to ripen fully before being picked, non-climacteric fruits taste their best. The table below provides a classification of climacteric fruits as well as non-climacteric fruits.

Table: Classification of Climacteric and Non- Climacteric Fruits

Climacteric	**Non- climacteric fruits**
Apple	Cherry
Apricot	Citrus fruits
Banana	Figs
Peach	Grapes
Plum	Melons
Papaya	Pineapple
Mango	Strawberry
Tomato	

Pectic Substances:

Carbohydrates serve as the starting point for pectic compounds. They are a polymer of galacturonic acid that has been methylated. They can be found in the primary cell wall of fruits and vegetables as well as the middle lamella of those cells.

The water-insoluble form of pectic compounds called protopectin can be found in immature fruits and, to a lesser extent, in vegetables. Protopectin is the name of the substance. Unripe fruits have a texture that is more firm because protopectin is present. The enzymes known as pectinesterases are responsible for some of the demethylation and hydrolysis that occurs along the protopectin molecules when fruit ripens.

It is a methylated water-insoluble polymer called protopectin that undergoes the transformation into a shorter methylated molecule called pectin, which is able to disperse freely in water. When pectin is heated in the presence of acid and sugar, a gel is produced.

Table: Pectic Substances and Gel Formation

Pectic Substance	Occurrence	Chemical characteristic	Capacity to form gel
Protopectin	Raw fruits and vegetables	Insoluble methylated polymer of galacturonic acid	Cannot form a gel
Pectinic acid	Slightly ripened fruits	Polygalacturonic acids containing more than a negligible proportion of methyl ester groups	Form a gel with very little sugar
Pectin	Optimum ripe fruits	Water-soluble shorter methylated compound	Forms firm gel with acid and sugar
Pectic acid	Over ripe fruits	Polygalacturonic acids free from methyl esters	Forms firm gel with acid and sugar cannot form gel

Pectin is degraded into shorter molecules that eventually lose all of their methoxyl groups. This happens as the process of pectin degradation continues. Pectic acid is the name given to those galacturonic acid polymers that are shorter in length. Overly ripe fruits and vegetables, especially those that are very mushy, contain pectic acid. The ability to form a gel, which is typical of longer methyl esters of galacturonic acid polymers, is no longer present in this particular type of pectic material.

As a result of the actions of a variety of enzymes during harvest, the constituents of the cell wall go through transformations. As the levels of two different kinds of enzymes, pectinesterases and polygalacturonases, rise, the pectic material that is found in cell walls and the middle lamella begins to degrade. Cellulase and hemicellulase are two examples of additional enzymes. Some sugars are liberated from the complex polysaccharides that make up the cell wall as a direct result of the processes that are catalysed by these enzymes. As a consequence of this, matured fruits become sweeter despite the fact that they may have very little or no starch, which may otherwise act as a possible source of sugar.

1.8 PROCESSING AND PREPARATION OF VEGETABLES

During the cooking process, vegetables should be handled with care in order to maintain as much of their nutritional content as is reasonably possible. Those vegetables are considered suitable for consumption in their natural state when they have a high water content, a high cellulose content, and a low starch content. There are several vegetables like these that are soft, crisp, and have a flavour all their own.

1.8.1- Preliminary Preparation

a) Washing

- The majority of vegetables are either grown on or very close to the ground. They are tainted with grime, sprays, sand, and a wide variety of bacteria of different kinds. It is vital to wash oneself completely in water.
- Vegetables that are consumed raw require a more thorough cleaning than cooked vegetables.
- In order to eradicate the insects, the blossoms of the cauliflower are washed in hot salt water.
- A large basin of water is used to soak the greens in. As the process continues, the impurities, including dirt and sand, sink to the bottom, and the leaves rise to the top. Washing vegetables in running water from the tap is one option.

b) Peeling

Before being cooked, both the roots and the tubers are peeled. It is preferable to remove the skin after cooking the carrots due to the following reasons: the nutrients that are contained under the skin will be drawn inside during the process of cooking; the skin can be readily removed after cooking; colour loss can be prevented; and the sweetness of the carrots is better kept.

c) Blanching

This is done so that harmful microorganisms are eliminated, enzymes are rendered inactive, the skin can be readily removed, and the colour is enhanced.

1.8.2 Different Methods of Cooking

a) Boiling in Water

This is one of the most popular approaches taken in private residences. The vegetables are washed, sliced, and then boiled in additional water for twenty to thirty minutes, after which the additional water is discarded. Because of this, a significant amount of vitamins and minerals that are water-soluble are lost.

b) Steaming

After being washed and sliced, the vegetables are placed in containers that only contain trace amounts of water and then steamed in a cooker at a pressure that is normal for twenty to thirty minutes. When using this type of cooking, there is only a small amount of any given nutrient that is lost.

c) Pressure cooking

After being washed and sliced, the veggies are placed in vessels that contain just trace amounts of water and then subjected to high pressure cooking in steam for ten to fifteen minutes. The losses of nutrients are comparable to those that take place when steaming at the same atmospheric pressure.

d) Roasting in Pan with Fat

After being washed, the vegetables are next sliced into smaller pieces. They are then placed in a heated pan that is seasoned with oil and various sauces. Some salt is included. The veggies are roasted for fifteen to twenty minutes, or until they have reached the desired degree of tenderness and doneness. When compared to steam cooking, this technique of preparation results in significantly higher levels of vitamin and mineral waste.

e) <u>Baking</u>

Baking can be done with certain kinds of foods, such potatoes and other similar foods, either in an oven specifically designed for baking or directly over an open flame. The amount of vitamin destruction is comparable to that which takes place when vegetables are cooked in oil.

<u>f) **Deep fat frying**</u>

There are some vegetables, such as potato chips, that are fried in deep fat. Because the temperature reached by the food during this way of cooking is high, the vitamins are destroyed by the heat and there is a significant loss of vitamin content as a result.

1.8.3 <u>Changes in Vegetables during Cooking-</u>

Changes during Cooking

Cooking vegetables brings out their natural colour, enhances their flavour, and transforms their texture, all of which contribute to an enhanced overall palatability. Additionally, digestibility is enhanced. The fibres become more pliable, the starch turns into gelatin, and the protein becomes more coagulated. Cooking eliminates microorganisms.

<u>Water Content</u>

- If the vegetable is cooked submerged in water or steam, there is a chance that some of the water will be absorbed.
- Baking is a process that results in the removal of water.
- A tendency for the cooked vegetable to become soggy when an excessive amount of water is absorbed.
- As the green leafy vegetables cook, they lose a significant amount of their volume and become more wilted.

<u>Cellulose and Peptic Substances</u>

When food is cooked, the cellulose and hemicellulose molecules become more flexible, and the pectic components go through some chemical transformations.

- Pectic compounds make it easier to chew and cut cooked veggies. This applies to both raw and cooked vegetables.
- The addition of sodium bicarbonate to the cooking water causes the hemicelluloses and cellulose to breakdown, which results in the production of a soft texture in a relatively short amount of time. Before adding potatoes to tomatoes or another acidic medium, you should first boil or fry them.
- Calcium chloride or a saturated solution of calcium hydroxide will have the effect of making the vegetable tissues more rigid by generating insoluble calcium salts with pectic components. Calcium chloride is added to canned tomatoes to keep them from becoming mushy over time.

Other Carbohydrates-

- The gelatinization of starch occurs during the boiling process; for example, potatoes become gelatinized during the boiling process.
- When potatoes are fried, a process called dextrinization of starch takes place.
- Simple sugars are produced as a result of the hydrolysis of starch, which takes place during the process.
- Sugar caramelises when it comes into contact with vegetables that have been charred or scorched, such as onions.

Protein

Protein gets coagulated completely or partly during cooking.

1.8.4 Loss of Nutrients during Cooking-

- Losses occur at the pre-preparation stage and continue throughout the process. For example, peeling an item can cause the vitamins that are present under the skin to be lost.
- Because carrots contain an important layer of nutrients just under the skin, you should scrape the carrots but not peel them very deeply.
- Because the leaves of beetroot root, carrot, and cauliflower are so nutritious, throwing them away leads in a loss of nutrients.

- Carotene can be lost when the outer leaves of cabbage are thrown away.
- Beetroot, carrot, and cauliflower leaves are particularly nutritious.

Solvent Action of Water:

Due to the fact that water has the ability to dissolve water-soluble nutrients, it is probable that these nutrients will be lost during the cooking process. The reduction of losses brought on by solutions can be accomplished by the application of the following strategies:

- Roughly chop the vegetable into larger pieces so that there is less likelihood that the vitamins will interact with the water. This will prevent the vitamins from being destroyed by the water. When carrots are cut lengthwise, less ascorbic acid is lost than when they are sliced crosswise. However, when carrots are sliced lengthwise, a greater amount of ascorbic acid is lost. It would be beneficial to cut down on the amount of time spent soaking or washing.
- In order to prevent the water-soluble nutrients from becoming dissolved in the water for a longer period of time, it is important to avoid allowing this to happen for as long as possible. It is best practise to wash the vegetables while they are still attached to their skins. Only after this step should you proceed to peel and slice the vegetables.
- Be certain that you are only utilising the tiniest feasible amount of water so that there is no surplus water at all.
- Permit to cook for a short while before removing from the heat. When anything is cooked for longer lengths of time, more ascorbic acid is released into the water, and this results in higher concentrations of the acid.
- You can correctly prepare the vegetables by steaming them or cooking them under pressure, but you shouldn't add any additional water to either method.
- Make sure that the container has a lid on it so that the cooking process may be completed more quickly.

- When you cook the vegetables with their skins on, you cut down on the number of vitamins that are leached out into the water during the cooking process.
- The water that is extracted during leaching can be exploited for culinary purposes.

Oxidation and Chemical Decomposition

- Nutrients can be lost as a result of chemical decomposition, which can be brought on by either the reaction of the water used in cooking or the heat itself.
- Vitamin C may easily be oxidised, and if the process continues past the point of producing dehydro-ascorbic acid, the vitamin's action is completely and irreversibly destroyed.
- Oxidation can be sped up by the action of enzymes, by heat, by an alkaline medium, by traces of copper, or by having unrestricted access to air oxygen.
- Oxidation of vitamin A can occur when the substance is subjected to dehydration or dry heat.
- Protection against losses brought on by oxidation or other forms of chemical breakdown
- Roughly chop the vegetables into larger pieces so that there is less surface area exposed.
- Make the cut, and start using it right away. Grinding will result in larger losses as a direct consequence of increased exposure to the air. When juice is extracted, there is a greater amount of waste.
- Put some water on to boil to get the cooking started. The initial minute or two of cooking time result in the largest loss of ascorbic acid compared to any other time during the process. This destruction is brought about as a consequence of the presence of oxygen as well as enzymes that are responsible for oxidation in the plant tissue.
- When the vegetable is put into the cooking process, water should be brought to a boil in order to force oxygen out of the tissues, which catalases the oxidation of ascorbic acid.

- Cover the pan so that there is no chance of the food coming into touch with the oxygen in the air.
- Ensure that the knife you are using is sharp. When cutting cabbage with a sharp knife, bruising is prevented, and less ascorbic acid is lost than when using a dull knife.
- The rate of destruction is accelerated as both the temperature and the amount of time spent heating the solution are increased. This is especially true when the solution is more alkaline.
- When cooked in the natural acids of certain foods like tomatoes, vinegar, tamarind, and lime juices, ascorbic acid is somewhat shielded from destruction. This is true to a limited extent. Baking soda consumption results in a greater loss of thiamine and vitamin C than does not using baking soda.
- After cooking, the food must be consumed right away; even if it is stored in the refrigerator, losses will still occur.
- Losses will continue to occur if the meal is not consumed right away.Even at a temperature of 1000 degrees Celsius, riboflavin and niacin are unaffected. Riboflavin is photosensitive and must be protected from it.
- Loss of riboflavin occurs in foods that have been left out in the sunlight before being cooked. Cooking does not deplete the body of its mineral content.
- Because there is less loss due to leaching in steaming and pressure cooking, there is optimum retention of the food's original nutrients. Steaming and pressure cooking are both excellent methods for retaining more of the vitamin C that is naturally present in raw vegetables.

Addition of Baking Soda

Baking soda is added to vegetables on occasion in order to enhance the colour of the food or to speed up the cooking process. Thiamine and vitamin C both become unstable when exposed to alkaline conditions. Heat losses are increased when an alkaline medium is used. Folic acid is also depleted when exposed to alkaline conditions.

1.9 MEDICINAL BENEFITS OF FRUITS AND VEGETABLES

Because man cannot subsist just on cereals, vegetables and fruits are an essential part of our daily diet and should not be skipped. Fruits and vegetables are vital components of a diet that is nutritionally sound and conducive to good health. Not only do they make the diet more visually appealing and interesting, but they also contribute a sizeable quantity of essential vitamins, minerals, and carbs, including roughage (fibre). Vegetables and fruits also hold therapeutic benefits.

The following is a list that highlights some of the most important nutritional benefits of fruits and vegetables:

- Fruits and vegetables both contain a significant amount of fibre. The consumption of food is reduced as a result of the satiating effect of fibre.
- Both the heart and the intestines can benefit from consuming fibre.
- It decreases blood cholesterol levels, which helps in the prevention of cardiovascular disease and lowers the risk of stroke.
- It regulates bowel movement, which helps to maintain a healthy digestive tract and lowers the chance of developing colon cancer.
- Folate, which is found in spinach, beans, and fruits like melons and oranges, helps prevent neural tube defects at birth.
- Potassium, which may be found in a variety of fruits and vegetables, including sweet potatoes, tomato paste, tomato puree, beetroot greens, white potatoes, white beans, lima beans, cooked greens, carrot juice and prune juice, helps to control blood pressure.
- Vitamin A promotes the health of both the eyes and the skin, and it also helps the body fight off infections. There are several fruits and vegetables that are rich in vitamin A, including sweet potatoes, pumpkin, carrots, spinach, turnip greens, mustard greens, kale, collard greens, cantaloupe, and red peppers. Sweet potatoes are particularly high in vitamin A.

- Vitamin C promotes healthy teeth and gums, which aids in the healing process of cuts and wounds.
- Vegetables and fruits (with the exception of olives, avocados, and coconut) are naturally low in fat. Excellent fruit and vegetable sources of vitamin C include red and green peppers, kiwi, strawberries, sweet potatoes, kale, cantaloupe, broccoli, pineapple, Brussels sprouts, oranges, and mangoes.
- Each variety of fruit and vegetable has its own unique set of nutrients, flavours, and textures to provide, making it an essential component of any diet designed to promote weight loss and good health. We need to consume a wide variety of fruits and vegetables to get the most out of our diets nutritionally.

1.10 BROWNING IN FRUITS AND VEGETABLES

The browning that occurs in fruits and vegetables is caused by an oxidative reaction known as enzymatic browning. When the skin of vegetables and fruits is sliced or torn, the cell wall is ruptured, which results in the release of an enzyme known as polyphenol oxidase, which then reacts with the oxygen in the surrounding air. As a consequence of this, vegetables and fruits may darken or become brown, which will result in changes in both flavour and nutritional content.

Measures to Prevent Enzymatic Browning

- The following are some ways that you can keep fruits and vegetables from turning rancid due to oxidation.
- To stop oxidative browning and preserve the colour of fruits and vegetables like potatoes and sweet potatoes, you can apply lime juice by squeezing it directly onto the surface of the food. It is also possible to make use of the juice extracted from other citrus fruits, such as oranges and grapefruits.
- To slow down the oxidation process, soak the sliced fruits or vegetables in plain water for a few minutes before storing them.

- The browning of fruits or vegetables can also be avoided by blanching them.
- Another effective method for preventing browning is to tightly wrap the food in cling wrap.
- Rusted knives and other iron metals should be avoided at all costs since iron speeds up chemical reactions. This is the most crucial rule.

1.11 LET US SUM UP

This unit discussed about different aspects of Fruits and Vegetables. Firstly unit covered the information about classification of fruits and vegetables as well as composition and Nutritive Value. The unit further includes detailed description about pigments and flavours present in **different** fruits and vegetables as these pigments and flavours is the major factor which add flavours in different cooking preparations. After that unit facilitates the information about processing, preservation post-harvest losses and loss of nutrients during cooking in fruits and vegetables. The final part of the unit discussed about medicinal benefits and enzymatic browning in fruits and vegetables. So the unit holds the detailed description of about all the important aspects of Fruits and Vegetables.

1.12 KEYWORDS

Fruits	----	Fruit refers to the mature ovary of a plant, including its seeds, covering any closely connected tissue, without any consideration of whether thes edible.
Vegetables	----	Any plant, edible or not, including trees, bushes, vines and vascular pl and distinguishes plant material from animal material and from inorg matter
Post-Harvest Changes	----	During storage, the fleshy tissues of fruits and vegetables normally und ripening after maturation and then continue to senescence known as I Harvest Losses.
Enzymatic Browning	----	Enzymatic browning is an oxidative reaction responsible for brownin vegetables and fruits.

CHECK YOUR PROGRESS EXERCISE

1- What do you understand by the term "Fruits and Vegetables"?

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2- Write down a short note on "Pigments of Fruits and Vegetables".

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3- Briefly explain about the Processing of Vegetables.

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4- Write down about Medicinal Benefits of Fruits and Vegetables.

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UNIT-15 SPICES AND CONDIMENTS

Structure-

1.0 OBJECTIVES

After finishing this lesson, students will be capable of:

- Know the definition and concept of Spices and Condiments
- Explain significance of Spices and Condiments
- Describe about different Extraction Process for Spices and Condiments
- Discuss Composition and Medicinal Values of Spices and Condiments

1.1 INTRODUCTION- SPICES AND CONDIMENTS

An essential group of horticultural products, spices and condiments have long been valued for their flavor-enhancing abilities in the culinary arts. Others have colourant, preservative, antioxidant, antibacterial, and antibiotic characteristics, and some are employed in the pharmaceutical, perfumery, cosmetics, and various other sectors.

Definition of Spices and Condiments:

The term "Spices and Condiments" refers to whole or ground natural plant products or combinations used as food adjuncts, primarily to add flavour, fragrance, and pungency to food. Additionally, it is used to flavour beverages and season meals.

Spices are organic plant products that are used in drinks, alcoholic beverages, pharmaceutical, cosmetic, and fragrance items as well as to enhance the flavour, aroma, taste, and colour of food products. India has long been referred to as the "Land of Spices." India is the only nation in the world with such a wide range of spice crops.

What Is a Condiment?

In general, a condiment is something "additional" that is added to meals for "flavour," to pique the taste buds, or even for its preservation qualities (like salt and vinegar). In other words, condiments are utilised for potential "taste satisfaction" rather than for any potential nutritional benefits.

A condiment: Is it a food too? Typically no. A substance that is consumed is either a naturally occurring component of the human diet or a nonfood object that has purposes beyond from providing nutrition. Condiments are either nutritionally inert or nonexistent.

A real food can be consumed in such quantities that it can stand in for a whole meal. You won't experience any negative consequences if you consume as much natural food as you want to feel satisfied and satisfied. Naturally, it is possible to consume too much of any food, natural or not, but generally speaking, you may eat several mouthfuls of a natural food relatively securely.

1.2 GENERAL FUNCTIONS OF SPICES

General Functions of Spices

- Spices make meals more pleasant, flavorful, and colourful, which increases diet variety. Due to the inclusion of various types of spices, grains, pulses, vegetables, and meat can be prepared in a number of ways.
- In general, spices promote the release of saliva, acid, and digestive enzymes. In order to facilitate the simple digestion of foods high in carbs, spices enhance the release of saliva containing more ptyalin. To aid with digestion and lessen gas, utilise spices.
- Spices can be antibacterial, anti-inflammatory, and antioxidant.
- Some spices support diabetics by enhancing the body's poor blood glucose levels.
- Some spices can help lower cholesterol and may even help avoid heart disease.
- Some spices are thought to be anti-carcinogenic or anti-mutagenic.

The cells in whole spices do a good job of protecting the flavour moiety from evaporation and oxidation. Whole spices release flavor slowly. Grinding spices release the flavor. Finer the powder, more readily available is the flavor.

1.3 PRODUCTION OF SPICES

Spices still hold the same respect they did in earlier times. In general, spices like cardamom, cinnamon, cloves, and black pepper are grown on a big scale in south India, while spices like chile, ginger, garlic, and onion are grown in Maharashtra. Over 9 lakh hectares of land are used to raise chillies across the country of India. States that produce the most include Andhra Pradesh and Karnataka. While Kerala, Meghalaya, Orissa, and West Bengal produce more than 60% of the nation's coriander, Rajasthan is the major producer. Garlic production is place in equal amounts in Gujarat and Madhya Pradesh. The districts of Idukki, Wayanad, and Kannur are the most heavily forested in Kerala, which is known as the home of the spice crop.

1.4 SIGNIFICANCE OF SPICES AND CONDIMENTS

The term "spices and condiments" refers to natural plant or vegetable products and combinations that are used whole or ground, mostly for flavouring foods and beverages such soups as well as for adding flavour, aroma, and piquancy to food. The application, blending, and power of spices to alter and improve the flavour of food is the great mystery and beauty of them. Because of their unique flavours, tastes, and aromas, spices and condiments have a special relevance in many aspects of human life. The majority of spices and herbs include active principles, therefore developing these through pharmacological, preclinical, and clinical screening would increase the likelihood that the product will be successfully commercialised. These goods that promote health can be made using spices. Phthalides, polyacetylenes, phenolic acids, flavanoids, coumarines, triterpenoids, serols, and monoterpenes, which are the active ingredients in spices, are potent agents for fostering both physical and mental wellness.

1. Spices improve the taste, colour, and appetizingness of food.
2. It encourages the release of acid and digesting enzymes like amylase.
3. It is antibacterial, anti-inflammatory, and antioxidant. It lowers cholesterol levels, which is beneficial for avoiding heart illnesses.

1.5 EXTRACTION PROCESS FOR SPICES AND CONDIMENTS

I. Extraction Techniques

A. Solvent Extraction: When using organic acids to selectively separate and concentrate a valuable substance from an aqueous solution, the process is known as solvent extraction. The solubility of the flavouring chemicals in the solvent affects the extraction process. By transferring the compound from the original (or first) solvent into a second solvent, a compound can be separated from contaminants in a solution. The chemical must be more soluble in the second solvent than in the first solvent, and the impurities must not be soluble in the second solvent for the procedure to be selective. In order to create two distinct solvent layers, the two chosen solvents must also be immiscible, or not soluble in one another. The solution is added to a second solvent after the mixture has been dissolved in the first solvent.

B. Solid Phase Extraction (SPE): Similar to liquid-liquid extraction (LLE), the fundamental idea behind SPE is the partitioning of solutes across two phases. SPE comprises partitioning between a liquid (sample matrix or solvent with analytes) and a solid (sorbent) phase as opposed to two immiscible liquid phases, as in LLE. SPE is normally carried out by placing the complicated material into an extraction cartridge that has already been preconditioned and contains a chromatographic sorbent.

C. Solid Phase Micro Extraction (SPME): A solvent-free sample approach called solid-phase microextraction is based on the sorption properties (adsorption or absorption) of fibre coating materials. An absorbent fibre coated with an ad(ab)sorbent polymer is introduced into the headspace before the analytes (volatiles or semivolatiles) from gaseous, liquid, or solid matrices are first released from the matrices and sorbed onto the fibre. Analytes are either thermally desorbed onto a GC inlet or solvent desorbed onto a high-performance liquid chromatographic (HPLC) inlet after sorption.

D. Steam Distillation: At high sustained temperatures, many organic molecules have a tendency to break down. As conventional distillation would then be impractical for separation, water or steam is added to the distillation equipment. The boiling points of the compounds are lowered by the addition of water or steam, allowing them to evaporate at lower temperatures, preferably below the temperatures at which the material begins to degrade noticeably. Vacuum distillation can also be used with steam distillation if the materials to be distilled are extremely heat-sensitive. Following distillation, the vapours are conventionally condensed, typically resulting in a two-phase system of the organic compounds and water that permits decantation.

E. Super Critical Fluid Extraction: Any substance at a temperature and pressure above its critical point, when separate liquid and gas phases do not exist, is referred to as a supercritical fluid. It has the ability to dissolve substances like a liquid and effuse through solids like a gas. Additionally, a supercritical fluid can have many of its properties changed because slight changes in temperature or pressure at the critical point cause substantial changes in density. In a variety of industrial and laboratory operations, supercritical fluids can replace organic solvents. The two supercritical fluids that are most frequently utilised are carbon dioxide and water.

F. Microwave Aided Extraction: Due to molecular friction, microwaves cause the bipolar rotation of polar molecules like water. Even though dried plant material is typically utilised for extraction, plant cells still contain very small amounts of moisture that are the target for microwave heating. Due to the plant cell expansion caused by the microwave effect, the moisture inside the plant cell heats up, evaporates, and exerts a great amount of pressure on the cell wall. The pressure forces the cell wall from the inside, straining and eventually rupturing it, which makes it easier for the active components to leak out of the ruptured cells. When compared to other methods, this one is incredibly quick and saves both time and a significant quantity of solvent.

G, Flavor Analysis: Both instrumental and sensory approaches can be used to assess flavour, however most scientists concur that sensory methods are most important for this particular qualitative trait. Instrumental approaches may identify tens or hundreds of different compounds in a given food product, but these techniques do not quantify the contribution of any one component unless they are combined with a sensory assessment of odour or flavour activity. Due to this, flavour may be the most difficult quality trait to quantify and link to consumer acceptance.

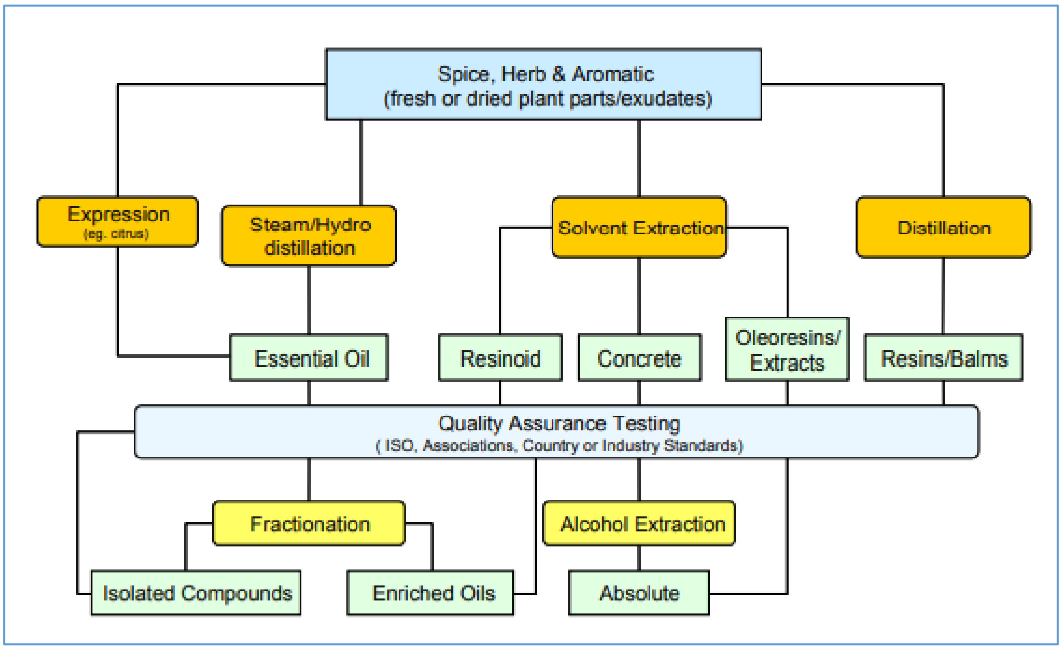
1.6 PRODUCTS OF SPICES AND CONDIMENTS

Primary Products-

Six broad categories can be used to classify the main harvesting materials used to make spices or essential oils: seeds and fruits, leaves and stems, flowers and buds, roots and rhizomes, and bark, wood, and resins.

Secondary and Derived Products-

Although there are many different secondary and derived goods, curry powders and other spice blends as well as substances taken from plant material such essential oils and oleoresins are the most often used. When the main spice does not match the quality requirements as a primary product, it is sometimes bought as a low-value product that has been extracted to generate the essential oil, oleoresin, or fragrance components. The commercial food processor can also benefit significantly from buying standardised extracts of established quality that are free of microbiological or other impurities. Spice flavours for use in food, beverages, or industry may arise from several extraction techniques.



<u>Extraction Processes used and Products from Spices, Herb and Aromatic Plants</u>

1.7 COMPOSITION AND MEDICINAL VALUES OF SPICES AND CONDIMENTS

1.7.1 <u>Ajwain(omum)</u>

Ajwain is a spice that is commonly used in curries because of its distinctive aroma and flavour. Thymol is naturally contained in the essential oil. It is utilised in beverages, pan mixes, namkeen, ompodi, rusks, pickles, and biscuits.

Medicinal Value

It is a common home treatment for heartburn. The antispasmodic, stimulating, and carminative properties of ajwain are well regarded.

1.7.2 **Aniseed (somfu)**

It uses volatile oil as its flavouring agent. Anethole is the main constituent of which. It is used as a mouth refresher and is chewed after meals. It can be found in pickles, vada curry, kurma, non-vegetarian foods, biryani, kachori, and cakes, breads, cookies, and candies.

Medicinal Value- Fennel infusions are used to treat flatulence. It is used to relieve colic discomfort and has a slight carminative effect.

1.7.3 **Asafetida**

It is an oleo gum resin that the ferula asafoetida rhizome or root secretes. Two substances that contribute to the smell are a ferulic ester and a volatile oil that contains sulphur. To tame the potent flavour, asafoetida is sold in the market combined with starch. It is a component of the seasonings for lemon rice, sambar, and rasam.

Medicinal Value: An antibacterial agent is asafoetida. It is also used to treat whooping cough and chronic bronchitis. It is employed as a digestive gas remedy. It raises the body's levels of detoxifying enzymes.

1.7.4 **Bay leaves (Birinj Leaves)**

They are the dried, fragrant laurel tree leaves. They have extremely volatile oil with an aromatic content of 1-3 %. The manufacture of pickled spices and the flavouring of vinegar both involve oil of bay leaves. The leaves are used to flavour meat dishes, pulav, soups, kadis, stews, fish, tomato pickles, and birinj desserts.

1.7.5 **Cardamom**

The fruit includes brownish-black seeds with a 2–10% volatile oil content and a distinct, pleasant aroma. The oil's active ingredients include pinene, sabinene, terpinyl acetate, cineole, and porneol. It is primarily used to flavour sweet dishes like cookies, bread, cakes, and jams.

1.7.6 Chilies

They come in a variety of sizes, shapes, and colour tones. The carotenoid pigment capsanthin is responsible for the red colouring of chiles. Scoville values are used to measure the heat of chilli extracts. The majority of Indian vegetable recipes and gravies contain ground chilli. Chutneys, pickles, dehydrated chiles, and everyday recipes all employ it. For flavouring, dry chilies are employed. Chilli and vinegar are used as a side dish in Chinese cuisine. Chinese cuisine also uses chilli sauce, chilli fish, chilli mutton, and chilli chicken. Gravies often contain fresh or powdered ground red pepper. The pungency of a chilli increases with its size. Chilli powder occasionally contains additives like sawdust, brick powder, and colouring agents.

Medicinal Value

A compound called capsaicin is found in peppers, and it promotes stomach secretion and damages mucosal cells. Chilies' capsaicin stimulates the digestive tract.

1.7.7 Cinnamon

It is the cinnamon tree's thin inner bark. About 1% of the bark's composition is essential oil. The active ingredients include cinnamaldehyde, cineole, and eugenol. Fruit preserves employ it in stick form. It is utilised in ground form in pickles, sauces, puddings, cookies, and cakes. For the creation of garam masala powder, cinnamon is employed. Cinnamon contains a flavonoid called methyl hydroxyl chalcone polymer, which functions as an antioxidant.

1.7.8 Clove

It is the clove tree's dried bloom bud. About 15% of it is made up of essential oil. The primary constituent of clove oil, eugenol, is a phenolic chemical and a naturally occurring antioxidant that stops food from going rancid. Esters of eugenol are utilised as flavourings. Fish, pickled foods, and meats all include whole cloves. In biscuits, puddings, and cakes, it is ground. It is a flavouring ingredient in fruit cake, rice puttu, and pulav.

Cloves are employed as flavouring and dietary supplements, especially in meats and bread products, because of their potent perfume and fiery, pungent taste.

Medicinal Value: Many homes use cloves and clove oil frequently to treat common mild illnesses including indigestion, flatulence, toothaches, and others. Its bactericidal and fungicidal qualities make it a good candidate for use as an antiputrescent in human medicine.

1.7.9 Coriander Seed

0.5–1% of seeds contain essential oil, which has the active ingredient coriander, an isomer of geraniol. The powdered, roasted seeds are a component of curry powders. In cooking, it serves as a flavouring and thickening agent. It is used as a powder in rasam, all curries, and powdered vegetables and chutneys. Samosas, kachori, and kaman dhokla all employ the entire ingredient.

Medicinal Value: For bad breath, dhania seeds are chewed. For nausea, vomiting, and intestinal ailments, coriander seeds are infused. Thalides, which are found in coriander seeds, raise the levels of cancer-preventing enzymes.

1.7.10 Cumin Seeds

It is harsh, astringent, and pungent. It has 2-4% essential oil in it. An aldehyde cumino serves as the active principle. The seeds are used in lassi, pongal, pulav, and rava pongal, as well as soups, cheese spreads, and chocolates. Additionally, it is a component of the curry, sambar, and rasam powders.

Medicinal Value: It functions as a stimulant and a carminative. Pthalides, which are bioactive compounds found in cumin seeds, raise the body's levels of anticancer preventive enzymes.

1.7.11 Fenugreek Seeds

The lentil seed is tough. It has an astringent scent and a dark fawn colour. 5% of seeds have bitter fixed oil. It has a bitter flavour and is used sparingly in sambar and kadhi seasonings. This enhances the flavour and preservation of pickles. It is always used in cooking with sour ingredients to lessen bitterness.

Medicinal Value: In diabetics who are not insulin dependent, fenugreek seeds help to maintain blood glucose levels. This might be caused by the seed's fibre content. Additionally, it is used in conjunction with butter milk to cure dysentery.

1.7.12 Garlic

Allin, which is an antibiotic principle found in garlic, is transformed to allicin, which is an active form, by the enzyme allinase. Allyl disulphide, which is how allicin further decomposes and gives off its distinctive flavour It is used in soups, sauces, pickles, chutneys, pulav, rasam, and the majority of non-vegetarian foods.

Medicinal Value: Various digestive diseases can be treated with garlic. Both gramme positive and gramme negative bacteria are resistant to its antimicrobial activities. Many pathogenic fungi belonging to the aspergillus and candida genera are known to be inhibited in their growth by the extracts of garlic and onion.

1.7.13- Ginger

It is the Zingiber officinale Roscoe plant's root. "Gingerol" is the volatile oil in the area. It has a lemony or camphorous aroma and is primarily pungent. The flavouring ingredient stimulates the senses in a harsh, scorching way. Dry ginger has a stronger flavour and is prized for the zest it imparts to more bland spices. For curries, pickles, chutney, and dried fruit preservation, the whole root is used. All non-vegetarian meals, such as pulav and pongal, as well as chutney, pickles, and salads employ ground ginger as a masala ingredient (mango salad). Tea, lime juice, and buttermilk are a few other drinks that use it. In murabba, ginger is used as a preservative.

Medicinal Value: Antioxidant properties are a known trait of ginger. According to some reports, ginger helps with joint discomfort and inflammation. Gingerol, a component of ginger, suppresses coughs naturally. Additionally, it may be used as a preventative measure to treat migraines. It might also work to make you feel less queasy.

1.7.14 Mustard

These tiny reddish-black seeds are found in annual herbs. This plant's leaves are eaten as vegetables. The flavour of mustard seeds is strong. An allyl iso thiocyanate gives mustard seed its distinctive flavour. The mustard paste is used to flavour salad dressings, cheese, hotdogs, sandwiches, eggs, and meat. Mayonnaise, sauces, gravies, and meat all include dry mustard. Pickles contain it in powdered form. It is a component in raitha and vegetable recipes. It is primarily used as seasoning. Cooking with mustard oil is another option.

Medicinal Value

Dithiol thiones, which guard against aflatoxin's harmful effects, are abundant in mustard seeds and are sulphur-containing chemicals. Dithiothione is also employed as an anti-istosomal medication.

1.7.15 Nutmeg and Mace

The dry, hard, wrinkled seed or pit of the nutmeg fruit is known as nutmeg. The nutmeg kernel's fleshy orange-red coating is known as mace. They have a 7–14% essential oil content. The highly poisonous component known as myristicin is present in this essential oil. Mace and nutmeg are used sparingly to flavour fruit pies and puddings. Mace, which is more subtle, is used to flavour some meat and fish dishes as well as fish sauces. It's a component of gramme masala.

Nutmeg seeds contain myristicin, which can cause delirium and a profound stupor. Nutmeg in smaller doses may produce colic and vomiting.

Medicinal Value

The antibacterial properties of Nut Meg. This feature is thought to be caused by the volatile ingredients in these spices.

1.7.16 Onion

It is a flavouring ingredient used in food preparations. It contains an essential oil whose active ingredient, allyl propyl disulphide, gives food its distinctive cooked flavour. As well as thickening gravies, it is used in cooking to improve flavour or cover up unwanted flavours.

Medicinal Value

It is thought that eating raw or cooked onions can help to keep blood sugar levels regular. The antimicrobial properties of onions. These plants' sulfur-containing chemicals have a potent antibacterial effect on both gram-positive and gram-negative bacteria. Numerous aspergillus and candida-related pathogenic fungi are known to be inhibited by onion extract. Onion is helpful in reducing cardiac illnesses and lowering blood cholesterol and lipid levels. The characteristics of onions include stimulant, diuretic, and expectorant. Dysentery and flatulence are helped by it.

1.7.17 Poppy seeds

They are tiny poppy plant seeds with a dark cream colour that are added to bread, cakes, rolls, and bun fillings. Salad dressings employ oil extract. When making gravies, poppy seeds are utilised as a thickening factor. Additionally, it is utilised in non-vegetarian foods, kormas, and desserts.

1.7.18 Pepper

They are a type of little, dried, spherical fruit found on a tropical vine with tiny, white blooms. The oleoresin in pepper is what gives it its pungency and aroma. The primary ingredient thought to be in charge of giving black pepper its bitter flavour is the alkaloid peperine. Due to the presence of volatile oil in the pericarp cells, pepper has its distinctive aromatic odour.

Crushed or whole peppercorns are both utilised. Many foods are seasoned with ground pepper, which is also served as a tableside condiment. Typically, whole peppercorns are added to stews and meat pickles. For general seasoning of meat, fish, poultry, vegetables, and salads, it is used ground. Use white pepper, which has had its black coat removed, in meals that call for a milder flavour. It can be used in place of chilli powder for making bonda, pongal, rasam, kolambu, vadai, and fried rice. Additionally, it is used to marinate non-vegetarian meals. Pepper powder can enhance the flavour of omelettes, sandwiches, salads, papads, soups, and chips. Sometimes papaya seeds are added to make it unwholesome.

Medicinal Value

It is useful for throat infections combined with heated milk. By accelerating absorption and delaying metabolism, the active ingredient piperine improved the bioavailability of other medications.

1.7.19 Saffron

This is the term used to describe the odorous stigmata present in crocus flowers. It is the most expensive spice in the world and has a regal perfume of matches. In order to manufacture one ounce of pure saffron, 75,000 blossoms are required. Each filament has a 700-fold water weight capacity for colouring. Its golden colour is primarily used. Saffron has a nice scent as well as the colouring agent crocerin and the essential oil crocin. It is used to give rice foods, especially soups and sauces, a bright yellow colour and distinctive flavour. Sandesh, Rasmalai, Thandai, Kesar Milk, Ice Cream, Halwa, and Srikhand are just a few of the desserts that employ it.

It might contain saffron styles, anthers, and corolla parts, as well as other things that have been dyed with coal tar.

Medicinal Value

Saffron treats eye infections and acts as a sedative.

1.7.20 Tamarind

This spice is made from the tamarind fruit's pulp, which has been stripped of its outer shell and seeds. Rasam and sambar are made with the extract. It serves as a souring agent in tamarind rice, chutneys, chat, pickles, and pani puris. Additionally, it is a gravy thickening agent. There are tamarind products on the market, including powder and puree.

1.7.21 <u>Turmeric</u>

It is the aromatic dried and ground root. It has 5% essential oil in it. Curcumin, the colouring agent present, is used.

Without the addition of additional spices, its naturally exquisite aroma can generate delectable food. It is ground and used in pickles, meat and egg dishes, curry powder, and as a food colouring in cakes and rice. It is utilised in marinating meat as well as lemon rice, sambhar, dhal, kadi, and kichidi. On occasion, lead salts or metanil yellow may be added to turmeric.

<u>Medicinal Value</u>: Turmeric's protective properties aid in the detoxification of hazardous medications or substances that are transformed into toxic metabolites. Turmeric aids in boosting the mucin content of gastric juice and lowering stomach irritability. Additionally, it is used to treat colds, coughs, sore throats, and flatulence. An effective anticancer agent is turmeric. Curcumin, the turmeric's main ingredient, is well known for its ability to suppress the growth of germs and fungi.

1.7.22 <u>Vanilla</u>

The "vanillin" active principle. Compared to natural vanilla, synthetic vanilla is far less expensive. It gives flavours and is a key ingredient in ice cream, custard, pudding, and cakes.

Although they are not spices, vinegar and monosodium glutamate enhance the flavour of food.

1.7.21 <u>Vinegar</u>

It's a staple in Chinese cuisine and a key component in pickling and preserving.

1.7.22 <u>Monosodium Glutamate</u>

MSG is sold under the Japanese brand name Ajinomoto. The sodium salt of the amino acid glutamic acid is monosodium glutamate. It is thought to stimulate the tongue's taste receptors, improving perception of the flavour.

MSG syndrome, which has been linked to monosodium glutamate, is known to manifest as a burning feeling, headache, weakness, and palpitations in the heart.

Even while using spices has numerous benefits, sometimes eating hot food can mask the nuanced flavours and odours of natural ingredients and even induce gastrointestinal problems.

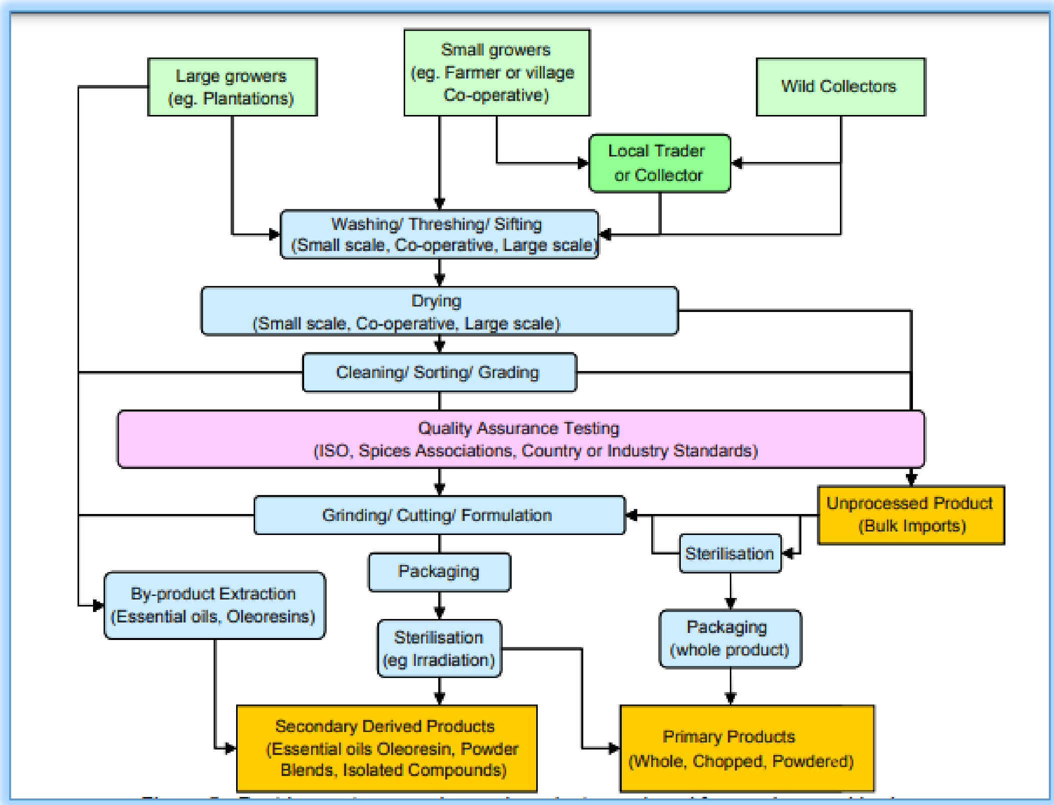
1.8 REQUIREMENT FOR EXPORT AND QUALITY ASSURANCE

Due to the climatic and manufacturing conditions under which they are created, spices, herbs, and vegetable seasonings can be highly contaminated with germs. Prior to being safely included into food items, the microbial load must be decreased. Due to the loss of volatile oils during high temperature processing, spices can significantly lose flavour and perfume. Color changes and the loss of volatile flavour and fragrance components are further effects of steam. The amounts of moisture might rise as a result of steam. Until recently, the majority of spices and herbs underwent sterilising gas fumigation, such as ethylene oxide, to eradicate contaminating microorganisms. Ethylene oxide use, however, was outlawed in several other nations due to its carcinogenic nature by an EU directive in 1991. Since then, irradiation has become a practical substitute, and when used instead of ethylene oxide fumigation, it produces cleaner, higher-quality herbs and spices. It is best to kill the microorganisms by irradiation, a cold, dry technique. Currently, commercial irradiation of herbs and spices is a common practise. Even though using irradiation as a single food preservation method won't completely eliminate post-harvest food loss issues, it can significantly lessen our reliance on chemical pesticides.

Under the auspices of the FAO, IAEA, and WHO, the International Consultative Group on Food Irradiation (ICGFI) has created a code of good irradiation practise for the management of pathogens and other micro-flora in spices, herbs, and other vegetable seasonings. The 9 irradiation's goal is to rid the seasonings for vegetables, spices, and herbs of pest insects and/or microorganisms. It is significant to emphasise that suitable drying, packing, and storing techniques are employed to preserve these substances rather than irradiation. Irradiation won't make any quality issues go away. The code describes threshold doses that result in organoleptic alterations, pre-irradiation treatment, packaging requirements, radiation treatments, and dose requirements for radiation disinfection.

1.9 POST PRODUCTION OPERATIONS

Although there is a path to the market through by-product extraction, the production of spices and herbs may be separated into a number of activities, and the majority of spices and herbs have a series of post-harvest operations that follow a logical sequence.



1.10 ROLE OF SPICES IN COOKERY

1. Spices serve as flavour enhancers. Payasam gains its distinctive flavour from the addition of cardamom. To enhance the flavour of pulav, garam masala is used.
2. Spices serve as colourants. Lime rice is coloured with turmeric. Rasmalai is coloured by saffron in addition to its flavour.
3. The pungency of spices. Chutney gains a bite from the addition of chillies. Tea, lime juice, or butter milk are among the drinks that ginger adds to that provide its smoky sensory stimulation.
4. As a preservative, spices work. Garlic, fenugreek, and mustard powder added to pickles have bacteriostatic properties.
5. In pulihoea, spices serve as a tangy ingredient similar to tamarind.
6. Spices work as a thickener. Poppy seeds, garam masala, and ginger-garlic paste are used in curries as a thickening agent.
7. As an emulsifier, spices. Because the chilli powder and dhania powder added to the oil serve as an emulsifying agent, the oil used as seasoning in sambar blends nicely and is not visible.
8. In Chinese fried rice, monosodium glutamate acts as a flavour potentiator, boosting the natural flavours of the rice and vegetables.

1.11 LET US SUM UP

Since spices and condiments are the elements that provide food flavour, they were discussed in this unit. Since solvent extraction and steam distillation are the two main methods for flavour extraction, this unit makes it easier to understand how flavour is extracted from various spices and condiments. The section then discusses chemical makeup and provides an introduction to various spices and condiments. The medicinal properties of the various spices and condiments are also covered in this unit. The lesson provides information on the importance of spices and condiments in cooking since they add various flavours to the food. Therefore, the unit contains all of the essential knowledge on spices and condiments.

1.12 KEYWORDS

Spices	----	Spices are organic plant products that are used to enhance the flavour, aroma, taste, and appearance of food.
Solvent Extraction	----	By using organic acids and a selective separation process called solvent extraction, a valuable substance can be isolated and concentrated from an aqueous solution.
Flavour Analysis	----	Both instrumental and sensory approaches can be used to assess flavour, however most scientists concur that sensory methods are most important for this particular qualitative trait.

CHECK YOUR PROGRESS EXERCISE-1

Monosodium glutamate	----	The sodium salt of the amino acid glutamic acid is monosodium glutamate. It is thought to stimulate the tongue's taste receptors, improving perception of the flavour.

1- What exactly do you mean when you say "spices and condiments"?

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…………………………………………

2- Write down a short note on "Flavor Extraction Process".

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3- Briefly explain about the different Spices and Their Medicinal Values.

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4- Write down about role of Spices and Condiments in Cookery.

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…………………………………………

Fill in the Blanks-

1. ……………………………………….are components derived from plants that are added to foods to alter their sensory qualities.
2. …………………………………..is a separation technique that uses organic acids to selectively remove one substance from another in an aqueous solution.
3. The distillation device is filled with water or steam, and the procedure known as…………………………..
4. ……………………………………believed to stimulate the taste receptors of the tongue enhancing perception of the flavour.

State weather the statement is True or False-

1. Curcumin is the name of the colouring agent in turmeric.
2. MSG is sold under the Japanese brand name Ajinomoto.
3. Turmeric's protective properties aid in the detoxification of hazardous medications or substances that are transformed into toxic metabolites.
4. The most important sensory techniques for this particular qualitative feature.