Uttar Pradesh Rajarshi Tandon Open University

UGHN 107- Principles of Food Science and Cooking

BLOCK INTRODUCTION

In this block we explained in detail about the Food quality evaluation requires instruments and physical and chemical methods. Food quality is subjective and objective. Unlike nutritional and microbiological quality, appearance, texture, and flavor are subjective.

In unit 1 we will study about the Food evaluation, their colloidal chemistry as related to food. Evaluation of foods involves instrumentation and use of physical and chemical techniques to evaluate food quality. Food quality has both subjective and non-subjective aspects. Appearance, texture, and flavour are largely subjective attributes, whereas nutritional and bacterial quality is not.

In unit 2 we will study about sugar, a building block of carbs, is naturally found in many foods like fruit, milk, vegetables, and grain. Added sugar, found in flavored yogurt, sweetened beverages, baked products, and cereals, is widely employed in industry. Monosaccharides and polysaccharides have several food business and nutritional uses. Sugars' other uses in food include preservation, antioxidants, color, flavor, and texture enhancement. High-sugar foods offer energy but are low in other nutrients, affecting the balance of minerals, vitamins, and proteins. Thus, excessive sugar consumption is harmful, especially during childhood, pregnancy, and aging. To stay healthy, limit sugary foods.

UNIT 1: EVALUATTION OF FOOD

STRUCTURE

1.1 Introduction

1.2 Colloidal Chemistry as related to food.

1.2.1. Colloidal system

1.2.2. Classification of colloidal system in food

1.2.3. Properties of colloidal system

1.3. Evaluation of food by subjective and objective method.

1.3.1Subjective method

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1.4. Let's sum it up

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1.1. INTRODUCTION

In this unit we will study about the Food evaluation, their colloidal chemistry as related to food. Food evaluation is an important aspect of food science that involves assessing the nutrition, safety qualities and sensory of food products. Quality of a food can be defined as the degree of excellence of food. Quality is the preferred attributes of any food product. The desired food is selected on the basis of factors such as its color, texture, flavor, the shelf life, its nutritional quality and as well as its keeping quality and bacteriological quality. The quality of food goes hand in hand with the acceptability of food .To monitor the quality of food it is important to measure both from the food safety stand point and to ensure the public interest for the product to choose it. The consumers today are demanding, discerning and have more knowledge about food. Therefore knowing about the consumers' preference is an important aspect for the food manufacturer and the caterers. The analysis of sensory is not psychophysics or vice-versa. The sensory science deals with the multidisciplinary area which comprise of measurement, interpretation and understanding of responses that produce properties perceived by the sense including smell, taste, sight, hearing and touch.

Objectives:-

The main objectives for evaluation of food are:

- To develop new products.
- To observe the reactions of the consumer.
- To identify what changes should be made in the menus so that food is acceptable
- To collect information of food acceptability.
- To assist the shelf life of the product

1.2. COLLOIDAL CHEMISTRY AS RELATED TO FOODS

The word colloid is derived from Greek work "kolla" meaning "glue" .It can be define as chemical mixture in which one substance is distributed evenly all through another

Colloidal chemistry as related food

substance but they do not combine to form any kind of solution. There are various types of systems depending on the state of the two substances mixed together.

Colloidal system gives texture, structure and mouth feel to various products.

Example: Ice cream, Jam and Mayonnaise.

Thomas Graham (1850) was the first to discover the existence of colloidal state. He is also known as the father of colloidal chemistry.

He classified the present of organic compound in food in two categories:

- Colloids
- Crystalloids

Colloids

Colloids can be defined as a mixture in which one of the substances splits into very minute particles which can disperse throughout a second substance. This minute particles are termed as colloidal particles. The colloids particles ranges from 1nm-1000nm.

Example: Proteins, Glycogen, Starch, agar-agar.

Colloids- a heterogeneous mixture

Here, Dispersed phase + Dispersion phase= Colloids

E.g. Flour + water

CrystalloidsCrystalloids are an aqueous solution small water-soluble molecules and mineral salts. The crystalloid solution that is commercially available are isotonic to the human plasma.

Example: Amino Acids and Sugar.

1.2.1. Colloidal System

A colloidal system is a heterogeneous system. The base of the system is made up of a material called as dispersion medium or continuous phase and the material that forms the colloidal condition is known as dispersed medium or discontinuous phase. In this system the microscopically dispersed insoluble particles of a substance is suspended in other substance. The suspended particles size range from 1-1000 nm (10^{-9}m). The mixture can be a colloidal only if the particles of suspension are not settled at the bottom. Colloidal solutions have the ability to exhibit the Tyndall Effect. Tyndall Effect is a phenomenon in which beam of light which is incident on colloids and scattered due to the interactions between the colloidal particles and light.

Food hydrocolloids are hydrophilic biopolymers with high molecular weight used in the food products so that it control their flavor, texture and shelf life. The classification of colloidal system in food can be into

Colloidal chemistry as related food

Colloidal chemistry as related food

Smoke	Solid	Gas	Smoked fish
Solid soil	Solid	Solid	Candies
Gel	Liquid	Solid	Jam and Jelly
Emulsion	Liquid	Liquid	Milk, Mayonnaise
Solid emulsion	Liquid	Solid	Margarine, Butter
Foam	Gas	Liquid	Whisked egg white, Whipped cream
Solid foam	Gas	Solid	Ice-cream, Bread, Meringue, cake

Colloidal chemistry as related food

different groups based on the states of matter constituting of two phases. They are gels, sols foam and emulsion. The emulsion and foam again can be further classified into solid emulsion/foam and liquid emulsion/foam.

1.2.2. Classification of colloidal system in food

System	Dispersed Phase	Dispersed Medium	Products
Sol	Solid	Liquid	Raw custard, unset jelly

Colloidal systems are classified into two separate phases based on their physical state:

(i) A dispersed phase (or internal phase) and

(ii) A continuous phase (or dispersion medium).

A colloidal system can be in the form of solid, liquid, or gaseous. The phase in which the substance is dispersed is known as the disperse phase and in which the substance is suspended is known as the continuous phase. **Example:** Air bubble trapped in the egg white act as disperse phase which result as foam and the egg white is the continuous phase.

Colloids are divided into the following kinds based on the sorts of particles in the dispersed phase:

1. Multimolecular colloids
2. Macromolecular colloids
3. Associated colloids

1. **Multimolecular Colloids**

When a high number of atoms or smaller molecules of a material mix on dissolution to create a species of colloidal size, the species is known as a multimolecular colloid. **Example:** Sulphur solution contains particles that have thousands of S_8 molecules.

2. Macromolecular Colloid

A appropriate solvent is used to generate a solution in macromolecules colloids. The particle size of the macromolecular solution varies with colloidal particle size. So, the solution is also called a "colloid of large molecules."

Example: Naturally occurring macromolecular colloids are Protein, Starch, enzymes, and cellulose whereas synthetic macromolecules include polyethylene, synthetic rubber, etc.

Colloidal chemistry as related food

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3. Associated Colloids

Associated colloids can be defined as those colloids that behave as normal strong electrolytes when at low concentration but at higher concentration they exhibit colloidal properties. This is due to the aggregated particles. The aggregated particles formed are known as micelles.

Examples: soaps and synthetic detergents.

The relative affinity of the dispersion medium, dispersed phase and colloidal dispersion further divide into two classes.

- Lyophillic colloids (water loving)
- Lyophobic colloids (water repelling)

Lyophillic is a term derives from “Lyo” which means solvent “Philic” is the power of affinity. Lyophillic colloids are mixture that is made up of a colloid which is strongly attracted to a liquid in which it is dispersed.

In lyophilic colloids the liquid and the colloidal particles have a strong attraction. The ingredient use to make a lyophilic colloid including gum, starch and protein. Hydrophilic colloids are lyophilic colloids that can disperse in water, and the dispersion formed in the mixture is the hydrophilic sol.

Example: Gelatin dispersed in water.

Lyophobic colloids are colloidal solution whose dispersed phase has very little affinity for dispersion medium. The solution of the colloid cannot be directly prepared and is known as lyophobic sol. This lyophobic sol are irreversible in nature.

Example: Oil dispersed in water.

1.2.3. Properties of colloidal system

Colloidal system can be distinguished from solution due to certain unique characteristics:

a) Tyndall Effect

One of the greatest methods to tell a colloidal dispersion from a solution is to use a powerful beam of bright light. When a strong light beam passes through a colloidal dispersion, a definite path can be seen due to the scattering or diffusing of light rays caused by colloidal particle deflection.

Colloidal chemistry as related food

b) Electric Charge

The colloidal particles are electrically charged. Some of them carries a positive charge (+) while others carries negative charge (-). The ionic charge for the given mass of materials is the same for all the charged particles.

(c) Adsorption

Colloidal particles have an ability to hold to the surface of the molecules of various gases, vapors and other matter when they come into contact. This phenomenon is known as adsorption. Adsorption has an important role in the character of colloid.

(d) Imbibitions

Colloidal has the potential to take up water and swell when it comes into touch with it; this property is referred to as imbibitions. Imbibitions are accompanied by the release of heat and other components such as acids and alkalis, both of which have a significant impact on the degree of swelling.

(e) Viscosity and Plasticity

Colloids encounter various degrees of viscosity and plasticity. Resistance to pour can be described as viscosity and the ability of solids to hold them in their shape under small pressure is called plasticity.

1.3. EVALUATION OF FOOD BY SUBJECTIVE AND OBJECTIVE METHODS

Food evaluation is a process in which the food product is analyzed to determine their nutritional, sensory and safety properties. This process includes using scientific methods for assessing the taste, aroma, texture, appearance, quality and nutritional value of the food.

1.3.1. Subjective Method of food evaluation

Subjective evaluation of food is based on judgments and personal opinion. These method measures the reaction of the consumers when they use or consume the product. A analytical and/or affective test is used to measures the consumer behavior and psychology along with the sensory aspect of the product. The traditional test is performed with trained panels whereas the affective test is run on the consumers. In this method a sheet of paper known as ballots is distributed to the evaluators when they receive the sample describing the information and instruction and the observation are recorded during the sensory test. The sensory characteristics of the products have

Colloidal chemistry as related food

Evaluation of food by subjective method

an important part of the food industry since long ago. The information that is obtained from the description of the sensory characteristics of food and beverages helps the companies to make the business more informed. Sensory profiling of any product helps the development team to change according to the consumer's desired sensory and to detect a detailed differences created by change of any ingredient.

Sensory evaluation of food

Sensory evaluation of food product is a scientific method that measures analyze and interprets the quality of food product with the help of senses of sight, taste, touch, smell and sound. This method for the analysis of food product has existed in some forms since the senses judge the quality and safety of the food. The sensory analysis evolved from the time human began to trade for food and its information. It also involves various formalized testing procedures, grading system and professional tasters. Some of the grading system are used in the modern era and have been used to evaluate coffees, tea and wines.

Rheology is used as an essential designing tool in food engineering for sensory evaluation. This is because rheology is important to shelf stability, processing and sensory perception which includes mouth feel and texture, it can also probe the overall structure and interplay between the individual colloidal compounds.

When the food is masticated a number of processes occurs which include deformation, comminuition, flow, mixing and hydration with saliva and also changes in size, shape, temperature and surface roughness of the food particles. These changes are difficult to measure with instruments but can be recorded with great sensitivity by the sense of human. The complexity of the events that occurs during mastication is not possible to be measured completely by instruments. There is no instrument which has elegance, sophistication, sensitivity and range of mechanical motion as the mouth.

Steps involve in performing sensory evaluation

1. Select the type of test you want to perform on the basis of what you want to find.

- **Preference test-** Asking whether they like or dislike the product. Example- Hedonic scale
- **Discrimination test-** Asking people about a particular attribute of the product. Example- paired comparison test.

Evaluation of food by subjective method

2. Find an area where the sensory test could be performed. The area should be away from noise
3. and cooking smell so that it does not distract the people who are participating in the sensory test.
4. Place the sample in a serving according to the number of people taking part in the test.

5. Code the sample with a random number, symbol, or letter.
6. Provide adequate glasses of water for participants to rinse their palettes after tasting each meal item.
7. Explain to those taking part what is expected of them, for example, the test they are taking and what they must accomplish.
8. Have them try one sample at a time and note their reactions. Allow enough time between samples for participants to record their thoughts.

Evaluation of food by subjective method

Evaluation of food by subjective method

Type of Sensory Test

Table: Type of Sensory tests

TEST	**EXAMPLES**
Discrimination test	Duo-trio test, Triangle test, Paired comparison test, Multiple standard test
Descriptive Test	Texture profile, Flavor profile, QDA
Affective test/ Acceptance/ Preference	Hedonic scale consumer studies
Other tests	Ranking test,

	Scoring

1. **Discrimination Test**

Discrimination testing is a technique that determine whether the two product has difference, the test requires group of panelists with appropriate training to test the discrimination from one product to other . The aim of this type of test is to evaluate specific attributes which include the characteristics of the products.

a. **Triangle test**
   - Three food samples are prepared out of which two are same.
   - The samples are arranged in triangle.
   - The taster decide which of the sample is odd one out
   - The responses are recorded.

b. **Duo-Trio**
   - Three food samples are prepared out of which two are same.
   - One of the two identical samples is used as control and the tasters decide which of the other two remaining samples is same as the control.
   - The tasters' response is recorded.

c. **Paired comparison test**
   - In this test the two samples are compared
   - The tasters are asked to identify the samples more designated characteristics like sweet.
   - The organization and implementation is easy
   - It is used to determine the threshold for the basic solution.

d. **Multiple sample test**
   - This test involves more than three samples.

- The separation of sample is in two groups of higher intensity and lower intensity.
- The test is descriptive
- It provides a complete sensory descriptive about the product.
- All the senses are taken into account.

2. Descriptive Tests.

A descriptive test is use to evaluate detailed profile of the food product's sensory attributes. It also measures the qualitative aspects of each attribute's intensity.

a. Flavor profile

- In this type of test 4-6 panel members are examine and discuss the given sample in open session.
- The leader summarizes the result in a report form once the agreement is reached.

b. Texture profile

This test provides a relationship between the instrument and results of the judges.

Evaluation of food by subjective method

3.Affective test.

An affective test evaluate acceptance, preference, liking or emotions in account of a product. They do not evaluate specific characteristics such as smoothness or crunchiness.

a. Hedonic scale

- The food sample is prepared
- The taster is asked to taste each sample and then tick a box from the rating scale which include from like very much to dislike very much which indicate there preference. The scale can be a 5-point scale or 9-point scale.
- The taster can also make remarks about the products such as appearance, taste, odor and texture.
- At the end the result is analyses according to the sample highest/lower score and then the sample preferred is selected.

3. Other tests

a. Ranking test

Evaluation of food by subjective method

to "vary". The responses are recorded.

b. Scoring

- In this type of test the food samples are scored on a scale lying between like and dislike
- The tasters are allowed to evaluate the sample and score their responses.

Importance of sensory evaluation

- Sensory evaluation helps to detect the similarities and difference of the similarities and difference of the given food products.
- It helps to evaluate the existing food product against the benchmark samples.
- The marked feedback help to analyze and improve the given product
- It analyzes specific response of the food sample that whether the food product is accepted or rejected by the consumers.
- The particular properties of the ingredient or the food product can be studied

- The attribute to be ranked is decided.
  E.g. smoothness, crunchiness etc
- The tasters are asked to evaluate the sample and place them in order of rank according to absent or presence of the attribute from "not at all"

- It can evaluate if the ready food sample meets the original specification of the standard sample.
- It obtains feedback data to make decisions and carry out suitable modification in a food product.

Demerits of sensory evaluation

- Every human differs widely in sensitivity likes and dislikes.
- The variables may be difficult to differentiate.
- It is an expensive and time consuming method.
- The standards are not accurate.

1.3.2. **Objective Method of Food Evaluation**

The Objective test is used to measure one particular attribute of a food at a time rather than overall quality of any product. When there is a development of new product, it is important to change the existing product, therefore the acceptance of consumer is an important aspect and though it may be reliable only objective testing is not sufficient,.

There are certain principles that must be drawn into attention while considering objective tests as a tool for evaluating the quality of food product:

- The objective test used for the food evaluation must be appropriate for testing the product. In other words, it must have the ability to measure the attribute of the food product which has a major effect on quality.
- The correlation of objective tests results should be with sensory testing of similar product so that it

Evaluation of food by subjective method

makes sure that the test is a reliable index for quality of the food.

- Most objective test that are used to assess food quality do not measure the absolute property of the food. However the results obtain are still meaningful till the instruments are calibrated with materials which have similar properties to the foods under test.
- In objective test all types of instrumental analysis which includes laboratory test that can determine nutritional decomposition, chemical composition and bacterial composition.
- Objective tests can be repeated and do not subject to human variation. If the equipment is used and

Evaluation of food by objective method

Evaluation of food by objective method

- Objective test plays an important role which identifies contaminants in food and also reveals the faulty processing methods along with the testing of deterioration and rancidity. Objective testing is essential routine to test quality control of foods and food products. However there must be a correlated with sensory testing as no single objective test can measure the overall acceptability of a specific food or the food product.
- Objective evaluation of food includes instrumentation and use of chemical and physical techniques instead of sensory organ of humans to evaluate the quality food.

Tests used for objective evaluation

1. **Chemical methods**

maintained correctly, it should give results that is realiable.

Chemical methods are used for the estimation of food spoilage which occurs when there is change in the normal state of food like peroxides in fats. Adulterants in food due o failing to meet the legal standard set by the government like presence of mashed potatoes in ghee, dyes and chemical in pulses and loss of nutrients during cooking can be estimated.

2. **Physico-chemical methods**

Physico-chemical method include various instruments such as the measurement of Hydrogen ion concentration in food with the help of pH meter, The concentration of sugar can be determine by refractometer and the quantitative analysis of sugar is done by Polariscope

3. **Microscopic examination**

There are some properties of foods that depend on the structure and valuable information which can be obtained by microscopic examination.

- Type of organisms which is present when the product is been fermented like idli batter.

- The starch cell is examine under the microscope for identification.
- The food spoilage can be obtain by observing the organisms under the microscope.
- Sugar crystal size is related to the product smoothness.
- Size and number of air cells in batters and foams.

Evaluation of food by objective method

Evaluation of food by objective method

4 .Physical methods

- **Weight**

  Weight of a food is used to determine the quality for example in case of egg or apple.

- **Volume**

  The measuring cups can be used to measure the liquid volumes, whereas displacement method is used to measure the solid food volume.

- **Specific volume**

  To measure the volume displacement with solvents like kerosene can be used.

$$\textbf{Specific volume} = \frac{\text{bulk volume}}{\text{Wt. of the substance}}$$

Instruments used for texture evaluation

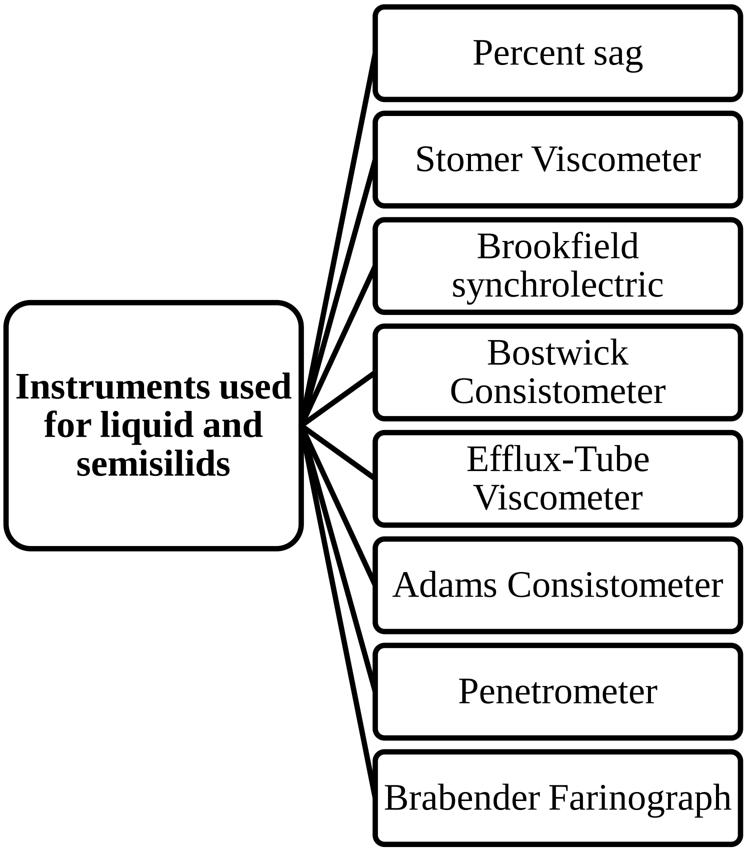
There are many instruments that are used to measure the texture of food such liquids, solids and semi solids. Rheology can be defined as the science of deformation and flow of a matter. It has three aspects viscous flow, elasticity, and plastic flow. Rheological properties of foods are important due to two reasons.

1. Determination of the flow properties of liquid food stuffs.

2. Ascertaining the mechanical behavior of solid foods when during processing and when consumed.

Instruments used for liquids and semisolids

Liquids and semisolids could be measured for the raw material of /or the product at various stages of manufacture serves and act as an aid in checking or predicting the consistency of the final product. Also, these quality control measurements serve as indicators to calculate the ingrideant. Following are some instruments used for liquids and semisolids:



Evaluation of food by objective method

- **Percent Sag**

  To measure the depth of a sample like jelly it is measured in a container by using a probe. The product is unmolded on a flat plate. The tenderness of the gel depend on the percent sag.

  Percent sag =

$$\frac{Depth\ in\ container\ - Depth\ in\ plate}{Depth\ in\ container} \times 100$$

- **Stormer viscometer**

This instrument measures the consistency or viscosity of the food products and gives index of resistance of sample to the flow. To measure the consistency of some food samples, the time taken by the rotor to make 100 revolutions is used

*Source: aadarshtech

Evaluation of food by objective method

- **Brookfield synchrolectric viscometer**

The Brookfield Dial Viscometer is used to determine the viscosity of a fluid at various shear rates. The Viscometer is capable of measuring a variety of ranges. The real viscosity for a given spring deflection is directly proportional to the spindle speed and is affected by the shape and size of the spindle. The resistance increases with the increase in spindle size and/or rotating speed for the substance whose viscosity is specified. The biggest spindle at the fastest speed is used to achieve the minimum viscosity range, while the smallest spindle at the slowest speed is used to obtain the maximum range.

Brookfield offered four basic spring torque series:

Model	**Spring Torque (Dyne-cm)**
LV	673.7
RV	7,187.0
HA	14,374.0
HB	57,496.0

Evaluation of food by objective method

***source : SPW Industrial**

- **Bostwick consistometer**

A consistometer is long and trough

and separated at one end by spring-loaded gate. The Consistometer is used for measuring the distance of a sample flows in a given time interval. The gated section if filled to the brim with the sample to use the consistometer, then the gate is release and note time how long it takes the liquid to spread to a pre-determined notch on the trough. The **Bostwick Consistometer** is the best choice for measuring the consistency and the rate of flow in variety of products.

***source: Scientific Gear**

Evaluation of food by objective method

- **Efflux-Tube Viscometer**

  The efflux cup viscometer is used for fieldwork in measuring the viscosity of syrups, oil, paints, and varnish and bitumen emulsions.

***Source: www.utest.com**

- **Adams Consistometer**

This consistometer was designed to measure the consistency of cream style, there are also use in measuring the consistency of other products like tomato puree, fruits pulps and apple sauce.

Evaluation of food by objective method

Penetrometer

A penetrometer is used to measure the tenderness of foods. The device consists of a plunger which is equipped with a needle or a cone that penetrate to the sample by a gravitational force for a selected period of time. If the reading is larger the distance will be longer and hence the product is the tenderer. Baked products and gels are particularly suited for the tenderness measurement using a penetrometer.

- **Brabender Farinograph**

The Brabender Farinograph is used to determine the flexibility of wheat dough before baking bread goods. Its purpose is to investigate the physical qualities of the dough by measuring the force necessary to turn the mixer plates through the dough. The force needed rises as the solution grows during mixing and falls when the solution is gradually broken down by overmixing.

*Source: Babender

Evaluation of food by objective method

Instruments used for solids

The measurement of resistance to force can be done by the reduction of Food texture.

Compression is the squeezing of food so that it remains as one piece e.g. bread.

Shearing can be define as the force applied so that one part of the food slide is past to another e.g. chewing gum.

Cutting is a process in which the force goes through the food so that it is divided e.g. cutting an apple.

Tensile strength is measured by applying force away from the food material so that the food is pull apart e.g. chapatti.

Evaluation of food by objective method

Evaluation of food by objective method

1. **Magness-Taylor Pressure tester (compression)**

   Magness-Taylor pressure tester has a plunger of variable diameter that is use for pressing into the depth of the given fruit. A sprint is attached to the plunger which is used to contracts and measures the compression force e.g.peas.

*Source: **www.textureanalyzers.com**'s

2. **Succulometer (compression)**

   The maturity of corn and storage quality of apples can be measure by using this instrument It determines the volume of juice extracted

   under a controlled conditions of time and pressur.

Evaluation of food by objective method

3.

4. *Source: **www.textureanalyzers.com**'s

3. Tenderometer (compression and shearing) Tenderometer is used to measure the tenderness of peas. Multiple needle is utilized as a probe that can be pressed into the food. The force that is needed can be sensed by a transducer and it is displayed on a meter. The engineered needle probe was carefully designed to give readings that are correlate with the tenderness of the meat after cooking, and at the same time it does not alter the raw meat for further use.

***Source: www.jbtc.com**'s

Evaluation of food by objective method

4. **Voldokevich bite tenderometer (cutting and shearing)**
   This instrument is similar to the action of teeth on food. It records at what force the biting of a piece of food has taken place and results in deformation.

This determines the total energy that is utilised for this deformation e.g. meat and meat products.

*Source:mecmesin

5. **Fibrometer**

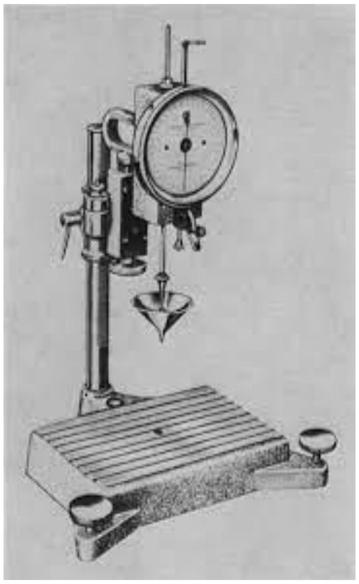
   This instrument is based on the principle of cutting and used in differentiating mature stocks from the tender stocks e.g. green beans.

***source:jcp.bmj.com**

Evaluation of food by objective method

6. **Shortometer**

   This device has a platform which contain two parallel, dull blades which is used for resting of the sample. A third blade is also present which is actuated by a motor so it can press down on the sample until the sample snaps. The force that is required to break the sample is the product tendeness measure.



***source:springer link**

Evaluation of food by objective method

7. **Succulometer**

   The moisture contain determine succulence or juiciness of a food product. Succulometer is design so that it measure the maturity of sweet corn. For this purpose, succulometer uses the principle of compression so that juice is squeezed out of food as a measure of succulence.

***source:tienda.welctr onics.mix**

1.3.3. Comparision between subjective and objective method of evaluation.

Subjective/Sensory	**Objective/ analysis**
Required individuals	Required equipment
Involves human sensory organ	Involve physicsl and chemicals techniques
Results varies	Results are repeatable
Determines by human sensory	Need to find appropriate techniques for food
Determines customer acceptance	Cannot determine the customer acceptance
Time consuming method	Time saving method
Essential for product development	Essential for routine quality control

1.4. LET US SUM UP

In this unit you have learnt about food evaluation and its importance in determining the quality. Food evaluation helps to determine and alter the changes required in the product so that the food is liked by the consumers. We have also learned about Colloidal chemistry in food and how it affects the properties of food. Lastly the objective and subjective method of food evaluation was discussed in details and what is the technique required to measure has been described.

1.5. ANSWER TO CHECK YOUR PROGRESS EXERCISE

1. What do you understand by evaluation of food?
2. How is colloidal chemistry related to foods?
3. Write short note on evaluation by subjective and objective method
4. How is subjective different from objective method

UNIT–II CHARACTERISTICS OF SUGARS AND STARCHES CARBOHYDRATES IN FOODS SOURCES

Structure

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2.2.1 Sugars: Chemistry and functionality
2.2.2 Role of sugar and effect of processing on carbohydrate
2.3 Characteristics of starches
2.3.1 Starches
2.3.2 Modified starches
2.4 Non-StarchPolysaccharides
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2.4.3 Hemicellulose
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2.7.5 Variable affecting batter quality

2.1 INTRODUCTION

Sugars are carbohydrates with a sweet flavor that are water soluble. Because of their functional features, they serve an important role in giving energy to the body and are employed in a variety of sectors such as food, medicines, and cosmetics. Carbohydrates are made up of carbon, hydrogen, and oxygen, although additional elements like nitrogen, sulfur, and even phosphorus may be present. The name "carbohydrate" (Carbon Hydrate) comes from the fact that hydrogen and oxygen are usually, but not always, present in a 2:1 ratio, as they are in water. This section examines carbohydrates in the human diet, including their classification as monosaccharides, di/oligosaccharides, and polysaccharides, as well as their functional qualities and application in diverse food items. Polysaccharides can be produced from a variety of sources, including but not limited to plants, algae, bacteria, and yeast. Plants are well acknowledged to be constituted of two basic types of polysaccharides. They are starch and non-starch polysaccharides (NSP), which are also referred to as dietary fiber. Dietary polysaccharides comprise microbial polysaccharides and algal polysaccharides in addition to exudates and seed gums. This section will look at several dietary polysaccharides. What are the qualities, attributes, and functions of food starches? What is modified starch, exactly? What role do they play in our diet? These are the subjects addressed in this unit's first portion. The course then discusses non-starch polysaccharides (NSP), microbial polysaccharides, algal polysaccharides, and gum exudates. The structure, characteristics, and functions of numerous dietary polysaccharides are described in this unit. This unit will be fairly detailed and extensive. To better understand polysaccharides, read the material carefully and take notes.

Objectives

After completing this course, you will be able to: understand the discipline of food science and the most recent advancements in this field; and appreciate the discipline of food science.

- To classify the carbohydrates.
- Elucidate the role of sugars in our diet.
- Elucidate starch and modified starch
- Describe the structural components, characteristics, and functional role of starches in food.
- Describe the significance of modified starches in the food business and at home.

- Elucidate the categorization of NSP
- Describe the structure, properties, and functions of several NSPs included in the diet.
- Describe batter and the function of applying it to culinary products.
- Identify several batter types and their application procedures in the creation of coated food products.
- Analyze the various elements and their functions in the batter mix.

2.2 CARBOHYDRATES

There is more carbohydrate (CHO) stuff in nature than any other type of organic material. This is because carbohydrates comprise the majority of the biological structure of all plants and are found to some degree in all animals. Sometimes, carbohydrates are referred to as "Saccharides," a term derived from the Greek word for sugar, sakchron. Monosaccharides are the simplest carbohydrates, yet they can combine to generate more complex carbohydrates (oligo or polysaccharides). In addition, a simple classification of carbs is offered in Table 1 for your information.

Table 1 classification of carbohydrate

Class (Degree of Polymerization)	Sub-Group	Component
Sugars (1-2)	Monosaccharides Disaccharides	Glucose, galactose, fructose Sucrose, lactose, maltose
Oligosaccharides (3-9)	Malto-oligosaccharides Other oligosaccharides	Maltodextrins Raffinose, stachyose, fructooligosaccharides
Polysaccharides (>9)	Starch Non-starchpolysaccharides	Amylose, amylopectin, modified starches Cellulose, hemicelluloses, pectins, hydrocolloids

Monosaccharides: These consist of the simplest carbohydrates. *glucose, fructose,*and *galactose* are the most prevalent monosaccharides found in the diet. $C_6H_{12}0_6$ constitutes the chemical formula for glucose. It can be depicted as depicted in Figure 1:

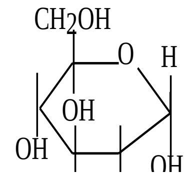


Figure 1: α**-D Glucopyranose**

Disaccharides:They are created when two monosaccharide molecules combine, removing one water molecule in the process. They possess the formula $C_{12}H_{22}0_{11}$. Examples of disaccharides are *sucrose (glucose and fructose), lactose (glucose and galactose),* and maltose (2 molecules of glucose). Figures 2 and 3 illustrate their respective structures.

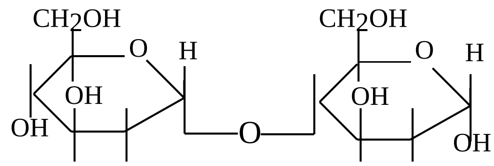


Figure 2: Maltose(a-D Glucopyranosyl (1-4) a-D Glucopyranose)

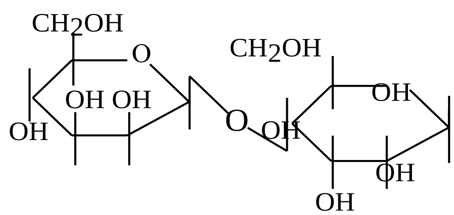


Figure 3: Lactose (b-D Galactopyranosyl (1-4) a-D Glucopyranose)

Polysaccharides: They consist of many monosaccharide molecules (often glucose) that are linked together. The typical formula for these compounds is (C6H1005)n, where n is a large number.Polysaccharides include starch, glycogen, cellulose, beta-glucan, and pectin as examples.

Having acquired a fundamental understanding of the classification of CHO, we will now recall the sources of carbohydrates in our diet. As you may well know, there are two primary kinds of carbohydrates: starch and sugars. The primary sources of glucose in our diet are starchy foods such as cereals, legumes, and potatoes, as well as sugar-containing foods and beverages such as milk, fruits and vegetables, jam, candies, table sugar, and some soft drinks. Approximately 60 percent of the total carbohydrate intake in the usual diet consists of starches, whereas the remaining 40 percent consists of sugars. Fiber is a collection of chemicals, primarily complex carbohydrates, that cannot be digested in the small intestine of humans but are fermented by bacteria in the large intestine. Cellulose, pectin, guar gum, and beta-glucan are some examples. The definition of fiber is non-starch polysaccharides (NSP). The constituents of fiber may have various effects on the organism. A small quantity of starch is not digested and instead goes into the large intestine, where it may be fermented by bacteria. This is known as "resistant starch" and may possess comparable qualities to NSP.

2.2.1 SUGARS: CHEMISTRY AND CHARACTERISTICS

This section will go over sugars, which are simple carbohydrates. Monosaccharides, often known as simple sugars, are carbohydrates that cannot be digested into simpler forms. Monosaccharides can have anything from 3 to 8 carbon atoms. From a chemical sense, these are polyhydroxy aldehydes or ketones. Carbohydrates can be aldoses or ketoses depending on whether an aldehyde or ketone group is present in the molecule. These are classified as pentose (5-carbon monosaccharide) or ketohexose (6-carbon monosaccharide) depending on the number of carbon atoms present in the structure. Table 2 provides a list of often occurring aldoses and ketoses:

Table 2 Common Aldoses and ketoses

	Ketoses	**Aldoses**
Trioses ($C_3H_6O_3$)	Dihydroxyacetone	Glycerose or glycerladehyde
Tetroses ($C_4H_8O_4$)	Erythrulose	Erythrose
Pentoses ($C_5H_{10}O_5$)	Xyloketose	Threose
Hexose ($C_6H_{12}O_6$)	Fructose	Ribose Arabinose
Heptoses ($C_7H_{14}O_7$)		Xylose

We shall not discuss the structure and properties of simple sugars in detail at this time. This course focuses on comprehending the functional role of these chemicals in our diet. Do consult Nutritional Biochemistry block 1, unit 1 for information on the structure and characteristics of CHO. This information is vital to your understanding of the roles of sugars, which we emphasize. But first, let's examine the most frequent sugar sources. The table below displays several sugars and their typical sources:

Table 3 Classification of Sugars, Sources, andCharacteristics

Classification	Source, Function, or Characteristics
MonosaccharidesPentoses	
Ribose	Derived from pentoses of fruits and nucleic acids of meat products & seafood, does not occur in free formsin foods, is analdose
Xylose	Is an aldose
Arabinose	Is an aldose
Hexoses	
Glucose	Fruits, Honey, Corn Syrup
Fructose	Fruits, Honey, Corn Syrup
Galactose	Does not occur in free form in foods
Mannose	Does not occur in free form in foods
Disaccharides Sucrose	Is an aldose, beet, and cane sugars, molasses, and maple syrup, and comes in many crystal sizes and grades.
Lactose	Milk and milk products
Maltose	Malt products, low concentrations in plants, and processed foods

2.2.2 Role of Sugar and Effect of Processing on Carbohydrates

Sugars are most usually associated with sweetness in the minds of consumers. Sweetness is fundamentally a physiological feeling. As a result, it must be assessed by humans; the sweetness of different concentrations of solutions is compared to that of regular sugar solutions until they taste similar. The sweetness ratio is obtained from the concentration ratio. Although sugar's most obvious function in foods is to add sweetness, it also serves a number of other functions in food systems. Crystallization, for example, plays an important structural function in confectionery manufacture. Sugar not only contributes to the browning of baked products, but it may also help to tenderize the product through its influence on the gelatinization of starch and denaturation of protein. Sugars, in addition to their sweet taste, have a number of additional functions that make them vital food components. They provide flavor and utility to cooking while also contributing to a healthy and diverse food supply.

1. Sweetness

The most well-known property of sweeteners is their sweetness. Our natural desire for sweetness is obvious immediately after birth, before postnatal learning, and diminishes with age. Sweetness is also associated with feelings of pleasure, appreciation, or reward, which contributes to the appeal of sweet meals. The combination of sugars and fats in confections generates a sweet flavor and texture that compliment each other. Sucrose adds sweetness to drinks without interfering with their delicate qualities. Table 4 compares the sweetness of many common sugars to sucrose, whereas Table 5 compares the water solubility of numerous common sugars.

Table 4 Sweetness of Sugars

Name	Sweetness
Lactose	0.16
Maltose	0.32
Glucose	0.74
Sucrose	1
Invert sugar	1.30
Fructose	1.73

Table 5 Solubility of Sugars in Water

Name	Solubility in grams/100 mlwater
D-Fructose	Highly soluble
Lyxose	Highly soluble

Maltose	108
D-Mannose	248
Sucrose	179
D-xylose	117
D-Glucose anhydrous	83
Raffinose	14
D-Galactose	10.3
Lactose	8

1. Texture

Sugars have an important role in food texture, often known as "mouthfeel." In ice cream, for example, glucose syrups create body and texture, which is perceived as smoothness. Adding sugar syrup helps to avoid lactose crystallization, which gives frozen dairy products a gritty or grainy feel. Confectioners can produce a broad range of textures by controlling the rate and degree of sugar crystallization. These range from the soft textures of fondants and fudges, which minimize crystallization, to the hard textures of hard candies, which crystallization produces the appropriate grainy or crystalline structure. Because honey does not crystallize, it can be used in confections to keep a soft and smooth texture.

Sugars are used in baking to provide taste, fragrance, and color. Excessive gluten development while mixing can result in hard, thick doughs and batters. The inclusion of sugar will keep gluten flexible, allowing the dough to expand and rise properly. During the mixing process, flour protein is encased in water, resulting in gluten strands. Within the strands, thousands of balloon-like pockets trap gases produced during leavening. Because of the very elastic gluten strands, the batter can stretch as the gases expand. Sugars fight for water with gluten proteins, inhibiting development and allowing for ideal volume and suppleness.

Sugars increase the rate of rise of the dough during leavening. The naturally uneven surface roughness of sugar crystals stimulates yeast growth and viability by providing an immediate and easily accessible source of nourishment. Yeast cells breakdown sugar crystals under favorable circumstances, producing carbon dioxide and enabling the dough to rise. Because shortening is used in the dough, air can become trapped in the naturally uneven sugar crystals. Air bubbles are disseminated throughout the mixture as the shortening and sugar are combined. These air cells expand with carbon dioxide and other gases from leavening chemicals during baking to create the correct volume. To keep the foam structure, the sugars naturally interact with the egg proteins. This makes the egg foam more elastic, letting it to expand when gas is absorbed during the leavening process. As water evaporates during baking, sugar recrystallizes, resulting in a crisp texture in baked goods. This crispness is increased by the browning (Maillard reaction) that occurs when reducing sugars and nitrogen-containing substances (such as protein) are cooked together. The browning process will be covered in greater detail later in this section, under the appearance function.

Sugars also help to tenderize baked foods by slowing the rate at which starch molecules interlink and proteins breakdown. To increase dough production and reduce excessive stickiness, glucose, fructose, sucrose, and maltose are used in the manufacture of bread.

Sugars ensure that unshortened cakes "set" correctly when baking. The egg proteins coagulate, or create connections, as the temperature rises. When the egg proteins coagulate, the firm, mesh-like structure of the cake "sets." Sugars diffuse among egg proteins and naturally interfere with bond formation, raising the temperature of formation.

The baking temperature causes the starch in the flour to swell owing to moisture absorption and solidify through gelatinization. The "setting" must be delayed until the leavening chemicals create the proper quantity of gases for a fine, uniformly-grained cake with a soft, smooth crumb. Sugars, being hygroscopic, inhibit the gelatinization process by competing for moisture with starch. This preserves the viscosity of the batter until the necessary quantity of gases are produced by the leavening chemicals, resulting in a final product with good texture and volume. The majority of cookies prefer surface breaking. When sugar re-crystallizes, it produces heat, which causes the water absorbed during mixing to evaporate. This reacts with the leavening gases to split and extend the dry surface.

2. Preservation

Sugars have an important role in the preservation of many items. The addition of monosaccharides, such as glucose or fructose, to jams and jellies decreases microbial growth and eventual degradation. Sugars have a strong affinity for water, slowing moisture loss in foods such as baked goods and prolonging shelf life. Honey and invertsugar, as well as sorbitol (sucrose alcohol) and corn syrup, aid to retain moisture due to their high fructose content.

Sugar is added to canned vegetables to keep them firm and to prevent oxidation when the can is opened. Inhibiting oxidation processes avoids not only texture and taste deterioration, but also pigment breakdown, which results in color loss. To prevent drying and staleness, the interplay of sugars and water regulates the moisture level of baked goods such as cakes and cookies.

Superior osmotic dehydration is based on the concept of osmosis and is anticipated to provide customers with better-tasting, more nutritious, and ecologically friendly dry goods (flow of water and dissolved compounds across the membrane to equalize this concentration difference). For a long time, osmosis has been used in the food industry. Plant or animal-derived foods are immersed in concentrated water solutions containing solutes such as sugar or salt. Water is transferred out of the food (dehydration) whereas solute is transferred into the meal (impregnation). Food's functional properties can be altered by varying the degree of dehydration and impregnation. The food industry is growing more interested in osmotic dehydration as a way of prolonging shelf life and enhancing overall product quality.

2. Fermentation

The production of chemicals by fermenting various sugars is a well-accepted science. Its use ranges from producing beverage alcohol and fuel-ethanol to making citric acid and xanthan gum for food uses. However, the high price of sugar and the relatively low cost of competing petroleum-based fuel has kept the production of chemicals mainly confined to producing ethanol from corn sugar - untilnow. Ethanol has been made since ancient times by the fermentation of sugars. All beverage ethanol and more than half of industrial ethanol are still made by this process. Simple sugars are the raw material. Zymase, an enzyme from yeast, changes simple sugars into ethanol and carbon dioxide. The decomposition of sugar during fermentation is identical to the reactions by which sugar begins to burn during respiration is very complex, and impure cultures of yeast produce varying amounts of other substances, including glycerin and various organic acids. We can split sucrose into glucose and fructose either using a strong acid, such as sulphuric acid or by an enzyme obtained from yeast, namely saccharase or invertase. In the production of beverages, such as whiskey and brandy, the impurities offer the flavor. Starches from potatoes, corn, wheat, and other plants can also be used in the production of ethanol by fermentation.

However, starches must first be broken down into simple sugars. An enzyme released by germinating barley, diastase, converts starches into sugars. Thus, the germination of barley, called malting, is the first step in brewing beer from starchy plants, such as corn and wheat.

The fermentation reactionare:

$$C_6H_{12}O_6 \longrightarrow 2\ CH_3CH_2OH + 2\ CO_2$$

Sugars, which are utilized to activate yeast for fermentation, play a vital role in the brewing and baking industries. By affecting the pace of fermentation, the kind and quantity of sugar added to the dough for baked goods can boost dough production. White bread's sweetness and softness are strongly influenced by sugars such as sucrose, glucose, and fermentable corn syrups. For hard-crust bread, sugars are either eliminated or used in considerably smaller proportions. In these bread, yeast is activated by sugars produced by the action of flour enzymes on starch.

Sugars remaining after fermentation impact flavor, contribute to the color and texture of crusts (through non-enzymatic browning and caramelization reactions), and affect the product's overall texture.

3. Appearance

a. Browning events are complicated events that occur during food preparation. In other circumstances, the black flavor is especially appealing and closely tied to the delicacy of the food. Coffee, maple syrup, the brown crust of bread and all baked products, potato chips, and many other processed items all require controlled browning. Browning during processing, on the other hand, is undesired in other meals because it results in a bad flavor, a dull look, or unsightly hues. It is critical to avoid browning while drying fruits and vegetables, preserving orange juice, or concentrating orange juice. The abundance of carbohydrates in meals is inextricably linked to the browning that occurs. Other compounds are occasionally important, but they share some of the reactive groups and properties of reducing sugars. The pigments produced are polymers with a high molecular weight and a difficult to discern composition. The browning reactions appear to be complicated not just in terms of the end outcome, but also in terms of the progression of multiple processes. It has been incredibly difficult to establish the chemistry of this change in the many combinations that are contained in almost every diet.

b. There are two basic types of non-enzymatic browning processes that occur during food processing:

c. a) Maillard process: The process that happens in the absence of oxygen between aldehyde and ketone groups of sugars and amino molecules (mainly amino acids, peptides, and proteins).

d. b) Caramelization: the process by which polyhydroxycarbonyl compounds (sugars and sugar acids) are cooked at high temperatures in the absence of oxygen.

e. Maillard Reaction:

The Maillard reaction, also known as nonenzymatic, nonoxidative browning, is simply the high-temperature reaction between the amino group of a protein, peptide, or amino acid and the reducing group of reducing sugar. Combining an amino group from a protein with an aldehyde or ketone group of a reducing sugar produces brown color and scent in a range of meals, including fried foods and bread. Intriguingly, the type of sugar and the type of amino acids determine the resulting "brown" color. The hue might vary from yellow to red. The trick here is decreasing the sugar content. Effective sugar reducers include fructose, glucose, maltose, galactose, and lactose. Surprisingly, sucrose, or table sugar, is not a reducing sugar. Due to the reactivity of glucose upon heating, the slight orange-red hue of browned bread crust is produced (Maillard reaction). Fructose caramelization provides a dark brown crust. Sucrose-containing bread typically produces a crust with a richer, deeper hue than glucose-based loaves.

f. Caramelization:

Caramelization is the result of 175 degrees Celsius heat acting on sugars. Sugars dry, disintegrate, and polymerize into thick caramels at high temperatures; the chemical changes associated with sugar melting create a dark amber colour and distinct tastes. Examples include the darkening of maple sap when heated to make maple syrup and the browning of bread when toasted, where caramelization occurs in the oven and the sugar adds a golden-brown, flavorful, and slightly crisp surface that tastes great and helps the product retain moisture. The caramelization process is responsible for a variety of browning reactions and taste changes. Sugars will caramelize once they reach the melting point. Each sugar requires a different temperature to caramelize. Galactose, sucrose, and glucose all caramelize about 160 degrees Celsius, whereas fructose caramelizes around 110 degrees Celsius and maltose caramelizes at 180 degrees Celsius. Caramel has a strong flavor, is often harsh, is much less sweet than the sugar from which it is formed, is noncrystalline, and is water-soluble. The type of sugar used in the cooking process influences the amount and rapidity of the caramelization event. The dark pigments produced are unsaturated polymers known as "melanins" or "melanoidins." Carbonyl or polycarbonate chemicals are required in both cases. Browning is delayed or abolished when carbonyl compounds are removed from a meal. Browning might occur as a result of chemicals entering at any stage.

The Amadori reaction happens before aldoses and ketose react with amines in the Maillard process. Figure 1.2 shows how the result of a chemical reaction can undergo a number of transformations depending on the reaction circumstances. It can lose water in neutral or acidic conditions and produce a ring complex of Schiff's base of hydroxymethyl furfural, or furfural, before removing the amine to generate free hydroxymethyl furfural, or furfural. It is capable of producing highly reactive reductones in its dry condition. Alternatively, the product may fission to produce tiny molecules such as acetol (CH3 COCH2OH), pyruvaldehyde (CH3COCHO), and diacetyl (CH3COCOCH3). All of these chemicals either react with amines to form aldimines or ketimines, or they polymerize to form aldols and other large molecules that then react with amines. The graphic clearly demonstrates this. The ultimate result is nitrogen-containing dark pigments.

Caramelization is the second process of browning. Caramelization occurs when sugars are cooked to relatively high temperatures. A high pH has a considerable impact on this sort of response. Browning of carbohydrates happens faster in the presence of carboxylic acid, salts of these acids, phosphates, and metal ions than in the presence of amino compounds. These compounds are often present in foods. Nitrogen-free intermediates produced by carbonyl amino browning reactions are also produced by non-amino browning processes. Through dehydration and sugar fission products, some model systems have demonstrated the synthesis of 1,2-enolization, furfural, and hydroxymethyl furfural. These intermediates have also been shown to form multicolored polymers in the absence of amino molecules.

4. FreezingPoint

Sugars effectively reduce the freezing point of a solution, which is crucial for the production of frozen sweets and ice cream. Most efficient at lowering the freezing point are monosaccharides and maize syrups containing a high concentration of low molecular weight carbohydrates. This feature results in fewer ice crystals and higher product smoothness. Additionally, the use of corn syrup sweeteners in sherbets prevents sugar crystallization and promotes a smoother result.

5. AntioxidantActivity

Numerous carbohydrates are effective metal ion scavengers. Glucose, fructose, and sugar alcohols (sorbitol and mannitol) can obstruct the reactive sites of ions such as copper, iron, and to a lesser extent cobalt. This feature of monosaccharides retards catalytic oxidation reactions, hence aiding in food preservation. In addition, it is recognized that Maillard reaction products have antioxidant effects on food systems. As a result, certain mixes of Maillard reaction products have been used in the food sector as additions to cookies, crackers, and sausages.

6. Other applications

Custards, puddings, pie fillings, and meringues rely on sugar to carry out critical chemical and physical processes.

a. Custards

While flour protein structures are responsible for baked goods, egg protein structures are responsible for custards. If the egg white hardens too rapidly while cooking, a process known as "Syneresis" or "weeping" occurs, in which liquid substances create droplets. Sugars prevent egg proteins from coagulating and break up clumps of protein molecules, letting them to spread uniformly in the liquid and provide a smooth, stable texture.

b. Puddings, Sauces, and PieCrusts

The structure of baked items is made up of flour protein, whereas the structure of custards is made up of egg protein structures. The liquid components will produce droplets if the egg white hardens too soon while cooking, a process known as "Syneresis" or "weeping." Sugars slow egg protein coagulation and break up protein clumps, allowing them to spread equally in the liquid and provide a smooth, stable consistency.

c. Meringues

Because the mechanical motion of the beaters causes the egg protein to partially coagulate, whipped egg whites contain air bubbles. Sugars increase the stickiness of the protein structure and its ability to hold air bubbles, resulting in a more stiff, stable, and voluminous form.

d. Icings

Sugars add sweetness, taste, bulk, and structure to icings and frostings. In addition to giving sweetness and flavor, icings act as a moisture barrier, extending the freshness period.

a. Frozen DessertApplications

Sugars make frozen sweets such as ice cream, ice milk, frozen custard, and sherbet creamier and more palatable.

Sugars including glucose, fructose, maltose, and lactose should be reduced in ice cream. To compensate for the lowered amount of butterfat in sweets with a lower fat content, such as ice milk and sherbet, proportions are increased. When the cream is substituted with lesser-fat ingredients, such as milk or fruit puree, more sugars are required to maintain a smooth, creamy texture and a balanced flavor.

b. Flavors and Mouthfeel

Sugars in frozen desserts balance flavor and texture. Since low temperatures tend to dull the taste buds, sugars intensify flavors, removing the need for extra flavorings. In addition, they increase viscosity (thickness) and offer a rich, creamy mouthfeel.

2.3 CHARACTERISTICS OF STARCHES

This section will discuss modified starches and modified starch. First, we will examine the structural components of starch, followed by a discussion of its qualities and a comprehensive examination of the various uses of starch in our food. The subsequent section will concentrate on modified starch.

2.3.1 Starches

Can you list several common sources of starch in the human diet? Yes, potato, wheat, rice, corn (maize), tapioca, and pasta are common sources of starch in the human diet. The percentage of starch in a variety of foods is shown in Table 6.

Table 6 Starch percent in different foods

Food	Starch (%)
Baby foods	3-5
Beverages (bottlers emulsion)	0.2-0.3
Marshmallows	0.5-1.0
Pie crust	0.5-1.2
Pie filling	3-5
Canned	4.5-6.5
Cooked	5-8
Instant	3-7
Butter sauces	0.3-0.5
Cake mix and icing	0.3-0.5
Pourable	1.5-2.3
Spoonable	2.8-5.0
Gum candy	5-12
Harvard style beets	2-4
Butter sauces	0.3-0.5

The principal carbohydrate resource found in plant tubers and seed endosperms is granulated starch. Starch is the second most abundant main carbohydrate produced by plants, behind cellulose. Starch is also the primary source of energy for many animals, including humans (60-80%). Because of its flexibility, consistent availability, and low cost, it is a very important component in the food industry. Starch is typically used as a thickener, although it may also be used as an adhesive, binder, encapsulating agent, filmmaker, gelling agent, water binder, texturizer, and fat-sparing agent, among other things, in the food and non-food sectors. This section will teach us about the many roles of starches. However, understanding its structure must come first. Let us look into the structure.

Characteristics and Structure

Starch is a polysaccharide made up of a long chain of glucose molecules. There are two kinds of glucose chains in starch. Figures 4 and 5 show a basic chain called amylose and a more sophisticated variant called amylopectin.

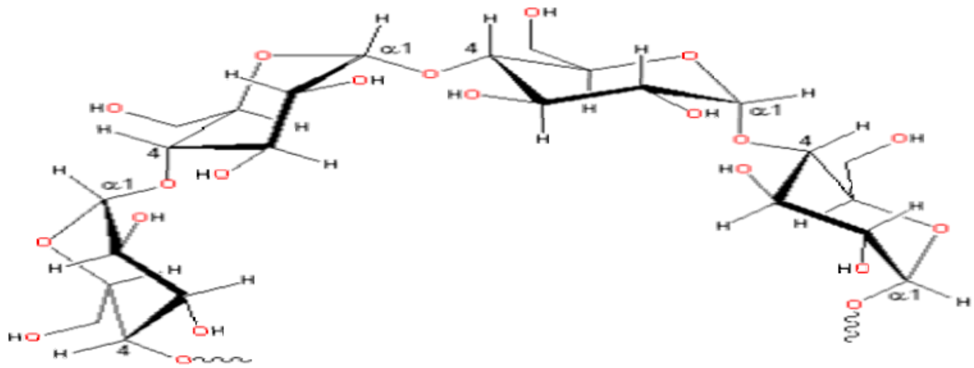


Figure 4: Structure of Amylose

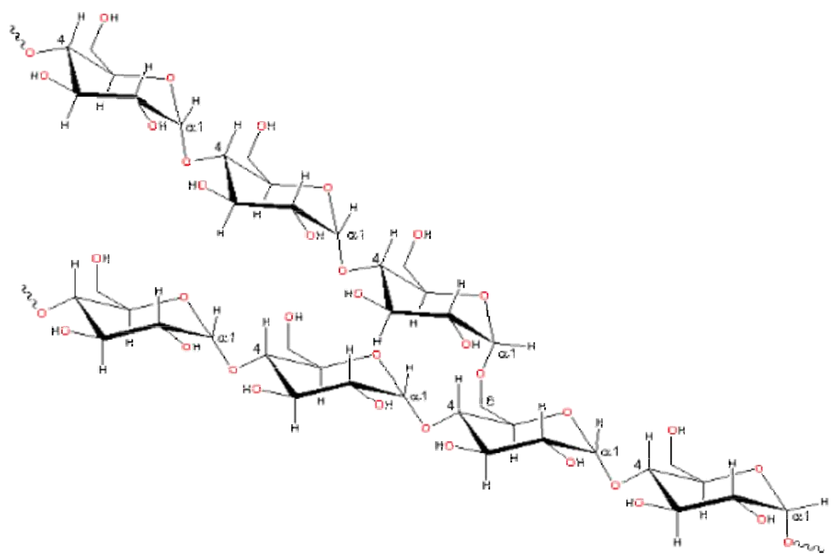


Figure 5: Structure of Amylopectin

The bulk of starch granules are composed of molecularly structured amylose (20-30%) and/or amylopectin (70-80%). Each granule typically includes several million amylopectin molecules, each of which contains several million glucose units, as well as a substantially bigger number of amylose molecules, each of which contains 500 to 20,000 glucose units. Amylopectin, the major component of most starches, is essential for granule formation. Amylopectin (without amylose) can be taken from "waxy" maize starch (so-called because the new surface appears vitreous or waxy when the kernel is split), but amylose (without amylopectin) is best extracted by hydrolyzing amylopectin with pullulanase. Let's study more about the structural components of starch, amylase and amylopectin.

A. Amylose

Amylose molecules have molecular weights ranging from 104 to 206. Amylose has the ability to develop an extended shape (hydrodynamic radius 7-22 nm), however it is more likely to form a left-handed single helix or even more stiff left-handed double helical junction zones. As seen in Figure 1a, the interior of the helix is entirely composed of lipophilic hydrogen atoms, whereas the hydroxyl groups are positioned on the coil's perimeter. The bulk of starches include about 25% amylose. The apparent amylose concentrations of two commercially available high amylose maize starches are 52 and 70-75 percent, respectively.

B. Amylopectin Amylopectin has a branching structure with around 30 glucose units bound together between branches. As seen in Figure 6, there are frequently more 'outer' unbranched chains (referred to as A-chains) than 'inner' branched chains (referred to as B-chains) (a). The solitary reducing group is contained in only one chain (referred to as the C-chain).

As previously stated, each amylopectin molecule contains up to two million densely packed glucose residues. Amylopectin's branching structure gives the molecule a striped appearance, with knotted branch tips in a row and smooth chains in between. These molecules are so large that they seem to form "growth rings" in the starch grain under a light microscope (see Figure 6). (b).

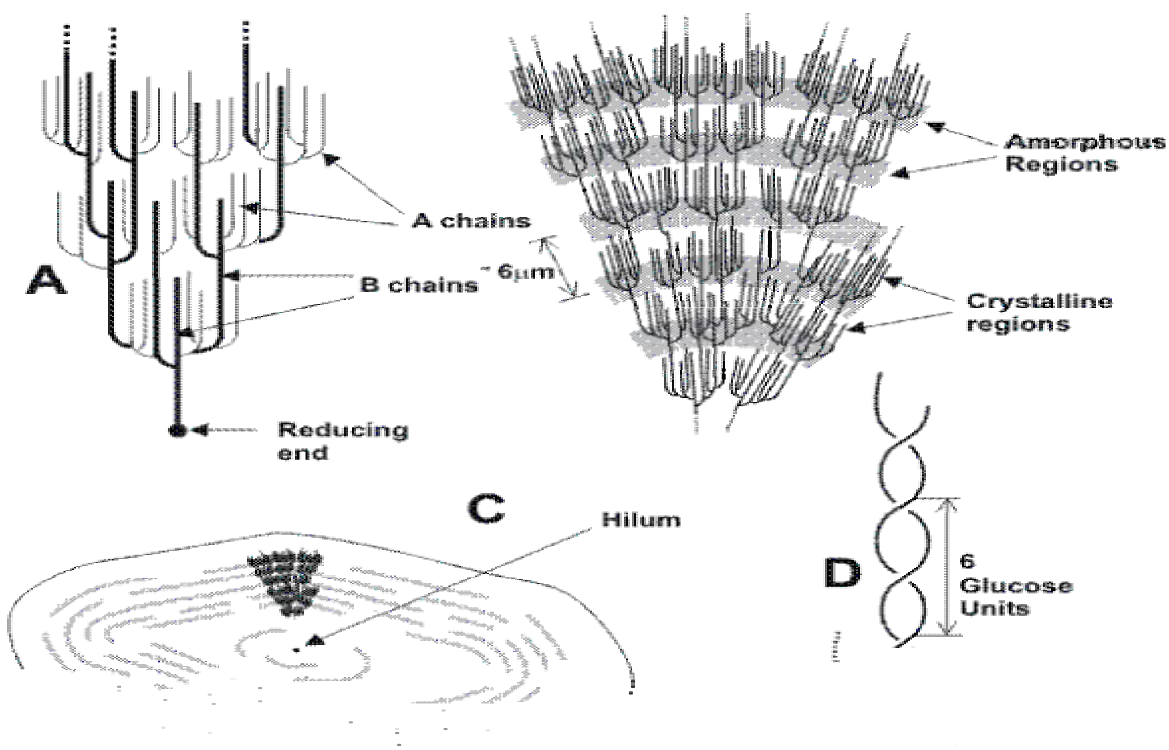


Figure 6: The amylopectin molecule

The salient feature of amylopectin and amylose are presented in Table 7.

Table 7: Function of Amylopectin and Amylose

Properties	**Amylopectin**	**Amylose**
General Studies	Highly branched	Essentially linear
Average chain length(glucose residues)	20-30	20-25
Degree of polymerization	10,000-100,000	10-1000
Molecular weight	10^6-10^8	10^4-10^6
Reaction with iodine	Red violet	Intense blue
λmax (maximum of iodine starch complex)	Approx.540nm	Approx. 660nm
Conversion into maltose (%) a) withβ-amylase b) with isoamylase, then with β-amylase	Approx. 55 Approx.105	Approx.100 Approx. 100
Iodine affinity (%)	1	19-20
Blue value	0.05	1-4
X-ray analysis	Amorphous	The high degree of crystallinity
Solubility in water	Soluble	Variable
Stability in aqueous solution	Stable	Retrogrades readily

Starch is bundled in granules in plants, which vary in form and size when isolated from various sources. These granules range in size from 2 to 150. The larger granules gelatinize more readily, but the smaller granules are more dispensable. In general, tuber granules are larger and spherical, whereas cereal granules are smaller and polyhedral. Granules derived from legumes may be kidney-shaped.

StarchProperties

Gelatinization and retrogradation are fundamental starch characteristics discussed below:

• Starch Gelatinisation: Starch is insoluble in cold water, but in warm water, it expands until it reaches its gelatinization temperature and begins to lose its structure and components. Gelatinization is the process through which a solid becomes a jelly-like material. Gelatinization is a chemical reaction that happens in the presence of heat and moisture. Cooking starch at 1,000 degrees Celsius breaks H-bonds, causing the granule to expand and the starch polymers to dissolve. The suspension thickens, becomes less opaque, and finally becomes a paste. Gelatinization is the term for this process. Water is absorbed during gelatinization, causing the starch granule to swell to many times its original size.

Let us discover more about starch gelatinization. When starch is heated with excess water, the molecular order of the granule is gradually and irreversibly destroyed at the gelatinization 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. When heated further, starch granules are broken and partial solubilization occurs. Total gelatinization typically takes place over a temperature range, with larger granules gelatinizing first. The full molecular solution is not reached at temperatures below 100° C, and the swollen hydrated granules containing the primary amylopectin remain. Continued heating of starch granules in excess water results in further granule swelling, additional leaching of soluble components (primarily amylose), and eventually, total disruption of granules especially with the application of shear forces. As a result of this event, a starch paste forms. The melting point of crystallites is 190°C. Gelatinization is an endothermic (10 mJ/mg) process, which means it is a chemical reaction accompanied by heat absorption.

• Retrogradation of Starch: After gelatinization, the starch paste or solution is not stable andtypically forms a viscoelastic, stiff, and rigid gel. During storage, structural transformations take place. As the starch paste cools and is stored, it becomes less soluble. In a dilute solution, starch molecules precipitate, and it is difficult to re-dissolve the insoluble material by heating. Retrogradation is the process through which dissolvable starch becomes less soluble. Retrogradation of cooked starch involves the component polymers amylose and amylopectin, with amylose retrograding at a significantly faster pace than amylopectin. When the starch polysaccharides are scattered, they reassociate. Amylose solutions rapidly gel when cooled to room temperature. Subsequently, some amylose molecules solidify slowly. Only at a temperature of 160 degrees Celsius can the gel be melted. Amylopectin crystallizes alongside gelatinized granules, although this relationship can be undone by heating it to 70°C. Consequently, following the retrogradation of a starch-water mixture, a partly crystalline polymer system is re-obtained.

Starches' functional characteristics

You are already aware that starch is the primary source of energy (calories) in grains, tubers, and dishes produced from these ingredients. However, when starch is added to products as an ingredient, its functional capabilities are typically more important than its caloric content. As Table 8 demonstrates, starches have a vast array of food applications, including adhesive, binding, clouding, dusting, film forming, foam strengthening, anti-staling, gelling, glazing, moisture holding, stabilizing, texturizing, and thickening.

Table 8: Functions of Starches

Functions of starch	Examples
Coating	Candles
Water Binder	Cakes
Free-flowing/ Bulking agent	Baking powder
Releasing agent	Candy making
Fat replacer	Salad dressing
	Baked goods
	Dairy products
Thickener	Puddings
	Sauces
	Pie fillings
Binder	Formed meats
	Breaded items
Encapsulation, Emulsion stabilizer	Flavors
	Bottlers emulsion

Starch is commonly used to thicken gravies, sauces, and desserts. Starch absorbs water and cooks into a gel, as you learned in the characteristics section. Amylose leaches out when starch swells with water, and amylopectin forms the gel. Some starches have a higher amylopectin concentration and produce better gels than others with a high amylose content. Keep in mind that the higher the amylose percentage for a particular starch concentration, the lower the swelling power and the weaker the gel strength. Amylose's major function is as a thickener (rather than a gel). The long water-soluble chains improve viscosity, which is unaffected by temperature fluctuations. Amylose chains' hydrophobic parts prefer to coil into helices (spirals). This allows them to trap lipid (oil and fat) and fragrance molecules within the helix.

Carbohydrates play an important part in the "mouth feel" of many food items and are used as fat substitutes since they are so excellent at absorbing water and swelling. Swelling power is determined after heating the starch in excess water as the ratio of the wet weight of the sedimented gel to its dry weight. It is determined by the processing conditions (temperature, time, stirring, centrifugation) and can be regarded as its water-binding capabilities. Carbohydrates with a high but relatively low water-binding capacity can provide meals body and texture. Starches are used as fillers, binders, moisture retainers, and fat substitutes in processed meat (hot dogs, sausages, etc.). They keep the material's form in extruded cereals, ready-to-eat breakfast cereals, and snacks.

A substantial amount of starch in the usual diet is resistant to breakdown in the stomach and small intestine and is referred to as "resistant starch." This amount, however, is difficult to estimate and is affected by a number of factors, including the kind of starch and the heating process employed before ingestion. Resistant starch is a dietary fiber that is defined as the sum of starch and starch breakdown products that are not absorbed in the small intestine by healthy people. It is an important source of substrate for gut bacteria, which create critical vitamins (and intestinal gas), as well as serving other important physiological activities. Physically inaccessible starch (RS1), raw ungelatinized starch (e.g., in bananas; RS2), thermally stable retrograded starch (e.g., in stale bread; RS3), and chemically modified starch (RS4) are the four types of resistant starch. Commercially accessible functional derivatives of starches include cross-linked, oxidized, acetylated, hydroxypropylated, and partly hydrolyzed material. For example, partly hydrolyzed (approximately two of eleven bonds) starch (dextrin) is used in sauces to modify viscosity.

2.2.2 ModifiedStarches

What, in your opinion, is the optimum starch for all industrial and culinary applications? One would think that the ideal starch for most meals would be able to produce a smooth texture with a heavy body but no gel phase, have a neutral flavor, produce a transparent solution and paste, and retain its thickening capacity at high temperature, high shear, and low temperature. Unfortunately, natural starches are incapable of satisfying such a wide range of desirable characteristics. Lack of free-flowing properties or water repellence of the starch granules, insolubility or failure of the granules to swell and develop viscosity after cooking, cohesive or rubbery texture of the cooked starch, particularly of waxy corn, potato, and tapioca starch, sensitivity of the cooked starch to breakdown during extended cooking when exposed to shear or low pH, absence of clarity, and tendency of the cooked starch

As a result, the native starches are modified to address one or more of the aforementioned limitations, hence expanding starch's industrial uses. As a result, modified starches are starches that have had one or more of their original characteristics altered by treatment in accordance with good manufacturing principles.

Modification of FoodStarches

Modifications that are minor and reasonably straightforward can significantly enhance the positive qualities of starches and/or reduce the unfavorable ones. The purpose of modifying native starch is to alter one or more of the following properties:

- The temperature of gelatinization and cooking properties.
- Solid correlations regarding viscosity.
- Retrograde attributes.
- Ionic personality.
- Resistance to viscosity changes brought on by the acidic environment, mechanical shear, and high temperature.

The natural starch can be physically or chemically modified. The chemical modification includes starch reacting with acid or alkali, and the resultant compounds are known as acid-modified starch and oxidised starch, respectively. For a long time, hydrolysis has been a common method of modification, and both vinegar and amylolytic enzymes have been used in this procedure.

Starch modification may also be caused by altering the mechanisms of starch biosynthesis by applying transgenic technologies to target and manipulate particular enzymes, resulting in the generation of new compounds with specific commercial uses.

When starches are heated in the presence of acid or alkali, the only major change is color; similarly, when starches are bleached, the only important change is color. The purposeful formation of a carboxyl group within a molecule is known as oxidation. If the 6-position is occupied for branching, substances such as orthophosphoric acid cause partial replacement in the 2, 6, or 3 positions of the hydroglucose unit. Cross bonding, in which a polyfunctional substitution agent such as phosphorous oxychloride links two chains, can be represented as starch -O-R-O-starch (where R = Cross bonding group and starch refers to the linear and/or branching structure). The commercial sample is defined by the parameter relevant to the kind of alteration, as well as the loss of drying, sulfated ash, protein, and fat content.

Starches can be altered physically and chemically to increase their performance. Pre-gelatinized starch is the most commonly modified starch. When combined with cold water, it instantly creates a paste. It is used in places where a cold-water paste is needed, such as convenience meals. Food starches that have been chemically changed or "TAILOR MADE" have shown to be the most successful in applications requiring exact process and product requirements.

Table 9 provides a brief overview of the various modified starches.

Table 9: Preparation and properties of modified starches

	Product	Methods	Properties	Uses
1	Acid-modified (Thinboiling)	Conc. Starch slurry + 1-3% acid; about 50^0C, 12 hr	Low paste viscosity, disintegrates easily, more soluble, higher GT, higher gel strength	Candy, textile laundry
2	Oxidized (thin boiling)	Slurry + alkaline sodium hypochlorite, pH 8-10, 21- 38^0C	Lower GT, easy pasting, low paste viscosity,more soluble, cold sol fluid, and clear	Oxidized starch has been applied in foods as coating and sealing agents in confectionery, as an emulsifier, as a doughconditioner for bread, as a gumArabic (an NSP) replacer, and as a binding agent in batter application.
3	Esters Acetate	Slurry + acetic anhydride; <50^0C	Lower GT, swells easily, higher peak viscosity, resistant to reassociation, cold sol fluid and clear, freeze-thaw stable	Provides excellent stabilizingand thickening performance for use in baked, frozen, canned, and dry foods, gravies, etc.
4	Phosphate monoester (anionic)	Starch+ phosphate salt; 120-140^0C	Being ionic, susceptible to salts. At 0.07DS, swells in coldwater.	Used as emulsifiers for vegetable oil in water systems and as pudding starches and thickening agents.
5	Ethers – Hydroxyethyl starch, hydroxypropyl starches	Slurry + alkali +ethylene oxide	Ether linkage is not cleaved by acid, alkali, or oxidation, hence can be usedunderdrasticconditions. Non-ionic, sounaffected by electrolytes.	Hydroxypropyl starchesfind applicationascoffee whiteners and thickenersin a multitude of food and food-related products. Theoutstanding storagestabilityand freeze/thawproperties of these starches makethem a premier product for the food industry.
6	Cationic starch Tertiary aminoalkylethers	Slurry+halogenated or apoxyalkylamine+ NaoH;40-45^0C,6-12hr, then acid	Active even at low pH At 0.07DS, swells in cold water. If very high DS, thermoplastic	Not often used for food purposes.

7	Cross bonded	Mixed anhydride phosphorous hypochlorite trimeta- phosphate, epichlorohydrin + alkali + heat.	Pasteviscosityis remarkably stable to cooking,temperature,acid, shear, and 'short' non-cohesive gel.Ifhighlycross-linked, doesnotswell.	Becauseofcommercially importantviscosity-textural properties, it is oftenemployedin conjunctionwith other types of modification such asoxidation, phosphorylation,and esterification
8	Pregelatinized	Slurry drum dried, extrusion	Swells in cold	All (convenience foods)

GT;Gelatinisationtemperature **DS; Degree ofsubstitution**

Uses of modified starches in food and confectionery industries

Visit a supermarket and search for instant sweets, jelly beans, salad dressings, tomato and pizza toppings, canned soups, etc. You might be astonished to learn that these and numerous other items include modified starches. In numerous goods, modified starches are utilized. Depending on how the starch has been changed, a variety of kinds are available, each with distinct functionalities. Starch and its role is depicted in Table 10.

Table 10: Types of starches and their action

Product	Modified Starch	function
Instant Desserts	Enables the product to thicken without requiring heat.	Starch is added in a pre-gelatinized form which swells in cold water, thickening the product without the use of heat.
Jelly Beans	Produces a very strong gel coating.	Starch is treated with an acid to produce a very strong gel. This forms the shell of the jelly bean.
Salad Dressing	Helps to stabilize an oil-in-water emulsion.	In French dressing, the hydrophobic part of the starch wraps around the oil droplet, so the hydrophilic (water-loving) part of the starch is in contact with the water. This keeps the oil dropletssuspended in the water.
Tomato and Pizza Toppings	Produces a gel that thickens on heating, preventing the topping from boiling over.	Starch is treated with a chlorine solution. This produces a get that thickens on heating and prevents the topping from spilling over. On cooling the topping flows.
Battered Fish	Improves the adhesion of the coating.	Oxidation of starch can improve its binding properties, which can be used to increase the stickiness of foods, such as batter applied to fish.
Canned Soups	Prevents the product from separating on standing.	Bonding starch with phosphate allows the starch to absorb more water and helps keep the ingredients of the soup together.

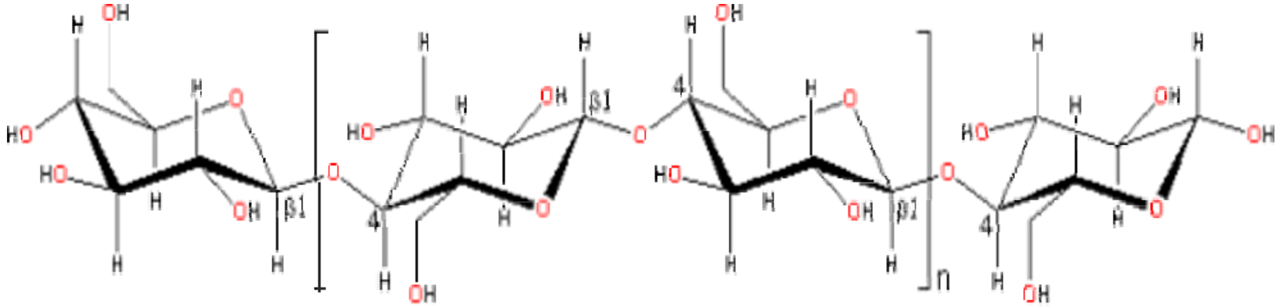
Oxidized starch has some applications in the food sector where a "bodybuilder" with a neutral flavor and low viscosity is required, such as in the production of lemon curd, salad creams, mayonnaises, etc. Oxidized starch has been substituted for gum Arabic in gum-drop and pastille confections due to its excellent film-forming characteristics. Oxidized starches produced from corn and waxy amaranth starch were compared with gum Arabic and a recognized alternative of gum Arabic for encapsulating vanillin, a model flavor component. It was discovered that adding 5 percent sodium alginate to oxidized starch enhanced the gelatinization rate and product stability when preparing jelly and marmalade. There were attempts to substitute gum Arabic with oxidized waxy maize starch in gumdrops.

2.4 NON-STARCHPOLYSACCHARIDES

Non-starch polysaccharides (NSP) are another term for dietary fiber (NSP). It refers to a class of chemicals found in plant cell walls that provide the plant structure and shape. It is made up of carbohydrates that are neither digested nor absorbed, but instead travel through the colon and are fermented for energy by bacteria, boosting their development. Because the term 'dietary fiber' refers to a nutritional concept rather than a dietary component, it has been proposed that it be phased out and replaced with the term 'NSP'; however, this has proven problematic due to the term's widespread use. Among the many NSPs are cellulose, pectin, gums, and beta-glucans. This section will look at the various non-starch polysaccharides. The principal polysaccharides in plant cell walls are cellulose, carboxymethyl cellulose, hemicellulose, and pectin. Find out more about them. We begin with the plant cell wall polysaccharides, cellulose.

2.4.1 Cellulose

Microfibrils of cellulose (2-20 nm in diameter and 100-40,000 nm in length) are found in plants.These form the framework for the structural integrity of the cell wall. The vast bulk of cellulose is made from wood pulp. From a structural aspect, cellulose is a 14-linked glucan, as seen in Figure 7.



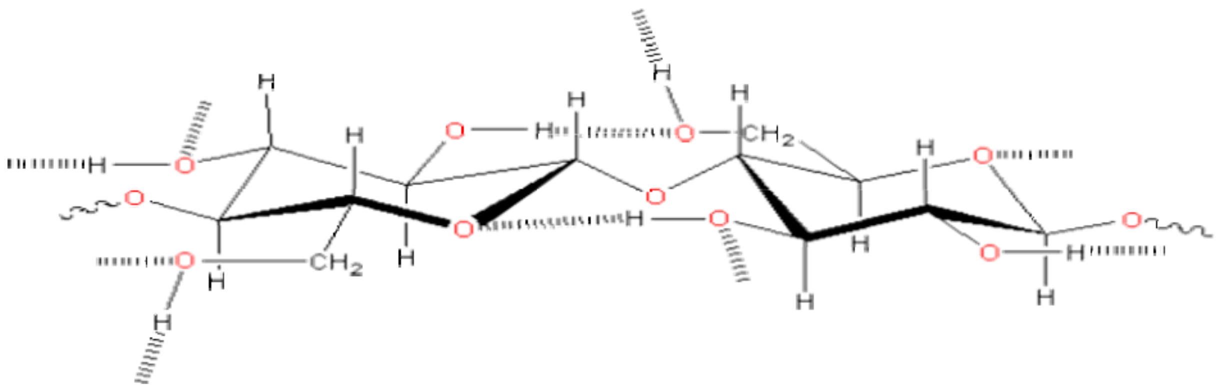


Figure 7: Structure of Cellulose

Functional properties of cellulose and its important role in various food applications:

Cellulose has several purposes, including anti-caking, emulsifier, stabilizer, dispersion agent, thickening agent, and gelling agent, however they are often secondary to its principal function of water retention. Dry amorphous cellulose absorbs water and softens to become flexible and pliable. While some of this water is not frozen, the vast majority is simply stuck. Direct hydrogen bonding binds less water if the cellulose has a high crystallinity, yet certain fibrous cellulose materials can retain a significant quantity of water in their pores and straw-like openings. This function may protect against ice damage due to the ultra cool ability of this water. Cellulose may provide volume and texture to sauces and dressings, especially when employed as a fat substitute, although its insolubility makes all products murky.

Swelled bacterial cellulose (e.g., Acetobacter xylinum) has pseudoplastic viscosity comparable to xanthan gels, but it does not lose its viscosity at high temperatures and low shear rates because the cellulose preserves its structure. Individual water-surrounded cellulose strands are flexible and lack continuous hydrophobic surfaces. One-third of the world's refined cellulose output is used as the starting material for a wide range of water-soluble derivatives with specified and varied properties. Methylcellulose thermogels (makes gels above a particular temperature by methylating roughly 30% of the hydroxyl groups). When such gels cool, they disintegrate, resulting in the lowest non-polar gas solubility. Hydrophobic saccharides become less soluble as the temperature rises. This property is important for creating coverings that limit water loss while retaining small gas bubbles. Although hydroxypropyl cellulose has a high surface activity, it does not gel because it forms open helical coils. Carboxymethylcellulose is another important cellulose derivative. Learn about its properties and culinary applications.

2.4.2 Carboxymethyl Cellulose(CMC)

CMC is a linear, anionic, long-chain, water-soluble polysaccharide. It results from the reaction of cellulose with alkali and chloroacetic acid. The structure is seen in Figure 8. Purified CMC is a tasteless, odorless, white to cream-colored, free-flowing powder. This property can only be preserved through proper packaging, as the substance easily absorbs atmospheric moisture.

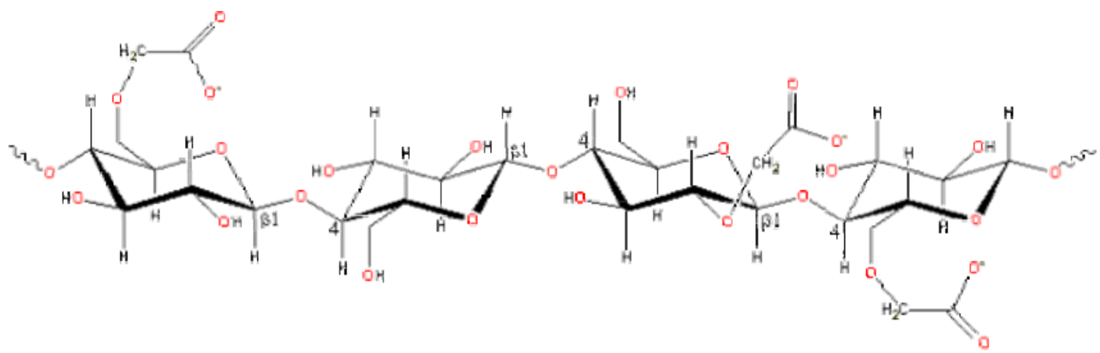


Figure 8: Structure of Carboxymethyl Cellulose

Functional properties of CMC and its important role in various food applications:

CMC is soluble in cold water and is primarily employed for viscosity control without gelation. As its viscosity decreases after heating, it can be utilized to increase the volume yield of baked goods by encouraging the development of gas bubbles. It can be used as a thickener, phase, and emulsion stabilizer (such as with milk casein), and suspending agent due to its viscosity control. CMC can be utilized for its great water-holding ability even at low viscosity, especially when used as a Ca2+ salt. Thus it is utilized for retarding staling and lowering fat intake in fried dishes.

In solution, CMC is compatible with the majority of common dietary constituents, including protein, sugar, carbohydrates, and other hydrocolloids. Similar to other water-soluble gums, it generates clear films by casting and evaporating the water from solutions. When these films are made using CMC with a high viscosity, their strength and flexibility are increased.

Similarly to other linear water-soluble polymers, cellulose gum solutions are pseudoplastic, meaning that viscosity reduces with increasing shear rate. The applications of CMC in the food industry are mentioned in Table 11.

Table 11: Food applications of CMC

Industry/Food	Function	Properties utilized
Baked goods	Adhesion, fat exclusion	Film formation, viscosity
Beverages	Body, texturizer, stabilizer	Rheological, dispersant
Frozen desserts	Texturizer, stabilizer	Crystal growth retarder, inhibition

Low-fat, low calorie Foods	Fat & sugar substitute	Rheological
Milk & yogurt drinks	Stabilization	Interaction with milk protein,dispersant
Pet foods	Binder, lubricant	Adhesion, rheological
Sauces, syrups & Toppings	Stabilization, thickening	Rheological

2.4.3 Hemicellulose

In plant cell walls, -cellulose with long fibers embedded in a matrix of cementing chemicals is the most prevalent component (matrix polysaccharides). These alkali-soluble molecules are known as hemicelluloses. They make up between 20 and 30 percent of plant cell walls.

Hemicellulose is a big polymer that helps give plant cells their structure. Hemicellulose imparts crisp, chewy, fibrous qualities to fruits and vegetables, which are partially retained after cooking. Together with pectin, it forms an amorphous matrix in which plant cell wall cellulose fibrils are embedded. As depicted in Figure 9, it has the chemical formula $C_6H_{10}O_5$ and consists of a chain of D-xylose sugar units with side chains of units of other sugars.

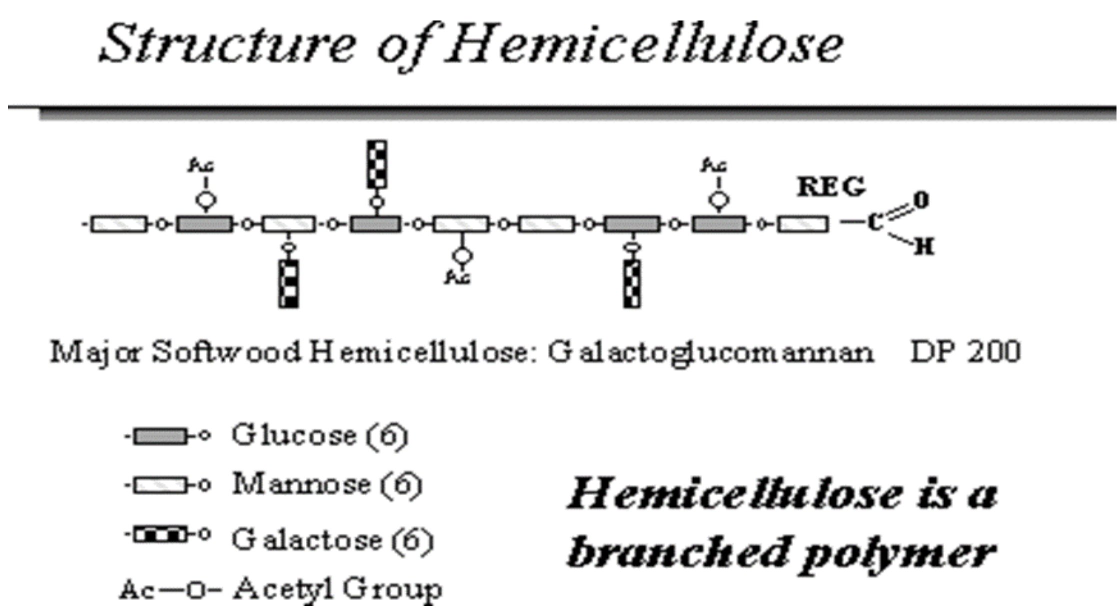


Figure 9: Structure of Hemicellulose

It has a lower degree of polymerization than cellulose, is more soluble in acid and alkali, and is non-fibrous. It mostly generates xyloses and other monosaccharides upon hydrolysis. Xylan, glucuronoxylan, arabinoxylan, glucomannan, and xyloglucan are examples of hemicelluloses. It is readily hydrolyzed by dilute acid, alkali, or hemicellulase (such as endo-xylanase, beta-xylosidase, and alpha-L-arabinofuranosidase for hemicellulose). Important hemicellulose sources include maize seed coats, cereal brans, wheat oats, barley, and rice. Other potential sources include sugar beet, potato, and tomato peels.

There are two types of hemicellulose: Hemicellulose A and B. Hemicellulose A precipitates upon neutralization of an alkaline extract and consists primarily of linear polymers, whereas Hemicellulose B precipitates upon the addition of ethanol to a neutralized alkaline extract (to a final concentration of 60-70 percent). Now let's examine the numerous nutritional impacts of hemicellulose, followed by its use in the food system.

Nutritional outcomes

Hemicelluloses fall within the classification of soluble dietary fibers. Hemicellulose is an indigestible, water-absorbing, complex carbohydrate. It is beneficial for increasing weight loss, reducing constipation, and decreasing intestinal carcinogens. A commercial product (based on -glucans) can lower blood cholesterol. When consumed in meals, oat and barleyglucans lower postprandial serum glucose levels, insulin response, and serum cholesterol levels. Hemicellulose can be transformed into a variety of fermentable compounds with added value, including fuel ethanol, xylitol, butanediol, and lactic acid.

Functional properties of hemicellulose and its important role in various food applications:

In food systems, hemicelluloses are used as an emulsifier, stabilizers, and binders in flavor bases, dressings, and pudding mixes. These substances may also be employed as bulking agents. These are excellent sources of fiber and boost the immune system. Corn fiber gum may be utilized as a low-viscosity thickener and/or emulsion stabilizer; for instance, corn oil/water emulsions are stabilized by corn fiber gum. It has potential utility in pourable dressings as well. It may also function as a fat substitute or mimic.

2.4.4 Pectin

The word pectin derives from a Greek word that means "to solidify or coagulate." Pectin is an acidic structural polysaccharide that occurs naturally in fruits and vegetables and is often derived from citrus peel and apple pomace (skin). As a structural polysaccharide, pectin is present in the middle lamella and primary cell wall of higher plants. Its structure is shown in Figures 10(a) and (b). Along with rhamnose, arabinose, and galactose, pectin is a polygalacturonic acid ester.

Pectin is also produced industrially from apple and citrus pomace and exported in pure and standardized forms. Low Methoxy Pectin (50% methylester groups), High Methoxy Pectin (>50% methylester groups), and amidated Pectin are the three primary forms of pectin.

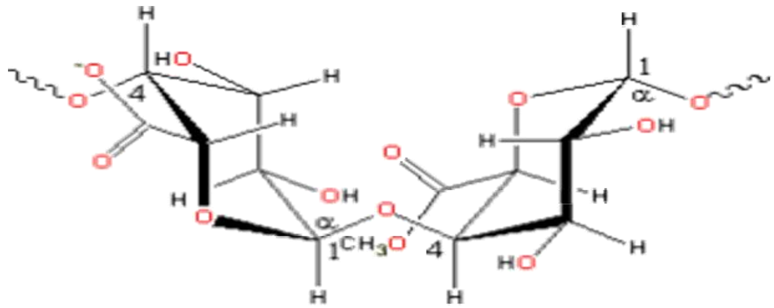


Figure 10 (a): Pectin: Smooth Structure

Figure 10 (b): Hairy Structure

In general, pectin is soluble in water but insoluble in the majority of organic solvents. As a result of its low viscosity compared to other plant hydrocolloids, pectin solutions have limited application as a thickener. In the presence of calcium and other divalent metal ions, low-ester pectin gels.

Functional properties of pectin and its important role in various food applications:

Pectins are predominantly employed as gelling agents, but they can also serve as thickeners, water binders, and stabilizers. Low methoxylpectins (50 percent esterified) form thermoreversible gels in the presence of calcium ions and at low pH (3 - 4.5), while high methoxy pectins form thermally irreversible gels rapidly in the presence of sufficient (e.g., 65 percent by weight) sugars, such as sucrose, and at low pH (3.5). The slower the setting, the lower the methoxy concentration. Using commercial pectin methylesterase, the degree of esterification can be decreased, resulting in a higher viscosity and firmer gelling in the presence of Ca^{2+} ions. It has been claimed that highly acetylated pectin from sugar beet has significant emulsification potential due to its increased hydrophobicity, but this may be related to protein contaminants.

As with other viscous polyanions such as carrageenan, pectin may be protective against milk casein colloids, so boosting the characteristics (foam stability, solubility, gelation, and emulsification) of whey proteins while using them as a source of calcium. Some pectin food applications are summarised in Table 12.

Table 12: Food Applications of Pectin

Product Group	Function of pectin	Pectin level (%)
Jams, jellies, and preserves	Gelling agent, thickener	0.1-1.0
Bakery fillings and glazing	Gelling agent, thickener	0.5-1.5
Fruit preparations	Thickener, stabilizer	0.1-1.0
Fruit beverages and sauces	Thickener, stabilizer	0.01-0.5
Confectionery	Gelling agent, thickener	0.5-2.5
Dairy products	Stabilizer, gelling agent	0.1-1.0

The preceding discussion centered on dietary fibers, namely plant cell wall polysaccharides. There are seven major kinds of fibers, including cellulose, hemicellulose, pectic compounds, gums, mucilage, algal polysaccharides, and lignin, which you may find intriguing. Cellulose, hemicellulose, pectin, etc. are plant cell polysaccharides. The most common of these fibers is cellulose. Gums are compounds that plants release in response to damage. In addition to being water-soluble, mucilages are used by plants to protect their seeds. From algae, algal polysaccharides are extracted. All of these are considered dietary fibers (also referred to as non-starch polysaccharides). Next, we will examine algal polysaccharides and learn about the structure and function of various algal polysaccharides.

2.5 SEEDGUMS

Polysaccharides extracted from plants and seeds have been utilized for millennia. Seed gums are a class of polysaccharides characterized by the following characteristics:

- Seed gums are light to dark cream-colored amorphous powders that generate viscous or transparent solutions when dissolved or dispersed in cold or hot water.
- They yield viscosities ranging from low to high, depending on their origin and manufacturing procedure. They have the property of producing high viscosity even at low concentrations (4500-8000 cP at 1% w/v), where cP=centipoise, the unit of measurement for viscosity. Seed gums are pH-stable across a broad range (3-9). Due to the nonionic nature of the polymer, the

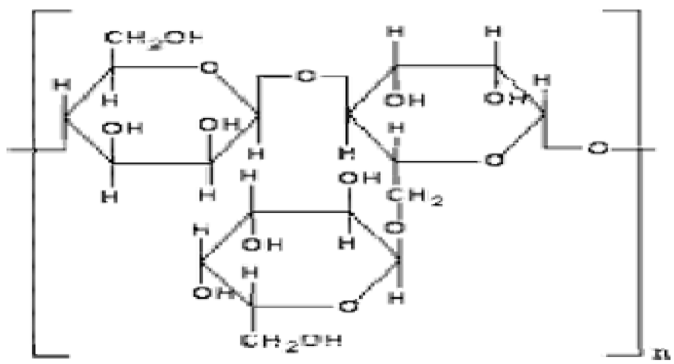
solution's viscosity is nearly constant.

- They have high compatibility with organic and inorganic substances, including certain food colorings and components.
- Even at lesser concentrations, they demonstrate efficient settling (flocculation) capabilities.

- The most prevalent seed gums are locust bean gum and guar gum. Next, we will study these seed gums.

A. Locust Bean Gum

Locust bean gum (also known as Carob bean gum) is derived from the carob tree's seed (kernels) (*Ceratonia siliqua*). Galactomannan galactose: mannose make up the structure of locust bean gum at a ratio of 1:4. Figure 11 depicts -linked mannan (1 4) linkage and (16) linkage in the side chain.



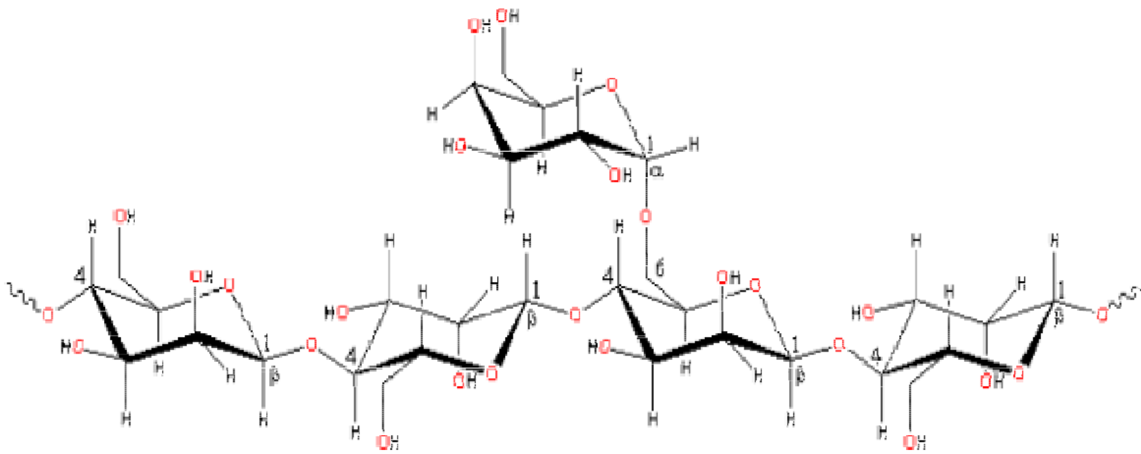


Figure 11: Structure of Locust Bean Gum

Properties of Locust bean gum

Locust bean gum is slightly soluble in room temperature water and must be heated to 75 to 85^oC for complete hydration and viscosity development. Maximum viscosity develops when the gum is heated to about 95°C, then cooled. Texture modification of carrageenan water gels is achieved through the incorporation of locust bean gum. Synergistic viscosity results from the combinations of locust bean and Xanthan gum. A thermally reversible gel is formed when locust bean gum and Xanthan are heated to above 130^oF andcooled.

Application in food

- In the food sector, locust bean gum has numerous applications. Let us concentrate on a few crucial ones:
- As a basic ice cream stabilizer, locust bean gum has been utilized. The addition of carrageenan and locust bean gum produces uniform dispersions of the ice cream mix. It inhibits the development of ice crystals by producing a structured gel at the solid/liquid interface.
- Locust bean gum is often utilized in cream cheese and similar goods. In addition to managing moisture in the final product, the application of locust bean gum produces a unique textural appearance.
- In specialized items such as salami, sausage, and bologna, locust bean gum is utilized as an additive. The viscosity imparted by the gum facilitates extrusion and stuffing. The gum's water retention property lowers the weight loss of the final product during storage.
- Adding locust bean gum to bread flour yields dough with consistent qualities and increased water-binding properties. Additionally, yields are increased and baked goods retain their softness and flavor for longer.

- From locust bean gum, potassium- and calcium-sensitive carrageenans, dessert gels resistant to syneresis were produced. Long storage periods at accelerated temperatures reduced syneresis to a minimum.

B. Guar Gum

Guar Gum is obtained from the seeds of the similar-looking legume *Cyamopsis tetragonalobus*. Guar gum consists of Galactomannan Galactose: mannose in a 1:1 ratio.

Application in food

- Guar provides smoothness to ice cream by encouraging the formation of microscopic ice crystals upon freezing.
- Guar gum in cottage cheese dressing increases curd integrity by reducing friction or turbidity, allowing the curd to slide during processing.
- Guar affects both the dough and the final product of baked items. In tomato-based sauces, guar helps to preserve the desired color while also adding body and stabilizing the system.
- Guar gum gives canned pet foods an attractive gloss or sheen. The friction-reducing property of agar also aids in the removal of pet food from the can.

2.6 EXUDATEGUMS

Most exudate gums come from compounds produced when the plant is wounded and these substances seal the wound. The most widely used exudate gum is 'gum Arabic' exuded from wounded trees of Acacia. Gum ghatti, gum karaya, and gum tragacanth are the other exudate gums. We will learn about these gum's heir structure and function in detail below:

GumArabic

Gum Arabic Gum Arabic or Acacia is the oldest and most popular natural gum. Gum Arabic is generated by thorny Acacia trees and Acacia Senegal (L.) wild or related species. Gum arabic is a complex and varied mixture of arabinogalactan, oligosaccharides, polysaccharides including glucuronic acid and 4-O-methyl glucuronic acid, and glycoproteins.

Properties

Gum Arabic is the most water-soluble natural hydrocolloid and can produce 55 percent solutions. Below 10% gum Arabic, solutions have low viscosities and Newtonian rheology. Gum Arabic is stable in acid solutions, making citrus oil emulsions shelf-stable. Electrolytes reduce viscosity even in weak gum Arabic solutions. Concentrated solutions lower this more. Due to its protective colloid activity, gum Arabic is widely used to prepare oil-in-water food emulsions over a wide pH range and in the presence of electrolytes without a stabilizing agent. Gum Arabic works with most gums, starches, sugars, and proteins. It does not work with sodium alginate or gelatin. Gum Arabic has many gastronomic uses.

Food Use

- Gum Arabic is used in confectionery to retard crystallization, emulsify and distribute fatty components. Jujubes and pastilles, when the main ingredient is high and the mixture low, use it.
- Gum Arabic is a common emulsifier in flavor emulsion concentration in the soft drink industry. Soft drink emulsion, which uses 30% of gum, uses gum Arabic as an emulsifier and stabilizer due to its protein content. Small amounts of whey protein concentrate selected for liquid emulsions can improve the functionality of inferior gum Arabic. Gum Arabic's foam stabilizing properties give beer and soft drinks the "lace curtain" effect on the glass's sides.
- Bakeries utilize gum Arabic because it absorbs little water. As an emulsion stabilizer and glaze/topping adhesive, it smooths.
- Gum Arabic makes stable, dry, powdered oil-soluble vitamins for food supplements. To stabilize oil-soluble vitamins, gum Arabic, an anti-caking agent like calcium or magnesium stearate, an antioxidant, and a chelating agent were mixed, dried, and crushed.
- Diabetic and dietetic baked goods use gum Arabic as a non-caloric bulking and bodying agent.
- Butter, margarine, topping spreads, and frozen desserts were stabilized with a 10:1 ratio of gum Arabic and Xanthan gum.
- Butylated hydroxyl anisole (BHA) is rendered water-dispensable and soluble by coating one part BHA with one part glyceryl mono-oleate and two parts gum arabic.
- Encapsulated flavors are used in most dry-package products, including desserts and pudding mixes, beverage powders, cake mixes, soup bases, etc. Spray-drying technologies rapidly dry a flavor-gum mixture in water to make such flavors. The gum seals and protects the flavor until it is released during food preparation.

Gum Ghatti

The Combretaceae tree *Anogeissus latifolia* exudes translucent, amorphous gum ghatti, often known as Indian gum. Gum Ghatti contains glucuronomannoglycan (uronic acid and mannose). The gum has a glassy fracture, and the exudates range from very light brown to dark brown, with the higher-colored material giving a better gum.

This will cover gum viscosity and pH effects. Gum ghatti forms viscous dispersions in water at concentrations of 5 percent or above and exhibits typical non-Newtonian behavior. From pH 7 to pH 12, viscosity decreases gradually. Viscosity increases with aging at all pH values. Ghatti's thick gel contains mostly calcium salt. Calcium ions can't reestablish viscosity when they're removed.

In butter-containing pancakes and waffle syrups, gum ghatti works well as an emulsifier and stabilizer with lecithin. In some applications, it fixes flavors.

Gum Karaya

Gum karaya (sterculia gum) is the dried sticky exudate *from Sterculia urens*, *Roxburgh*,and other species of *Sterculia* (Family: Sterculiaceae) or *Cochlospermungossipium* or other *Cochlospermunkunth* (Family: Bixaceae). Indian tragacanth is gum karaya. Gum Karaya is acetylated rhamnogalacturonan (rhamnose and galacturonic acid).

Properties

Gum karaya absorbs water quickly to generate viscous colloidal dispersions at low concentrations. Gum karaya is highly sticky at 20–25% concentration. Without preservatives, gum karaya dispersions lose viscosity over time.

Food Use

- Karaya's water-absorbing, water-holding, and acid compatibility made it ideal for ice pops, water ices, and sherbets.
- Karaya effectively prevents free water (with dissolved flavor and color) and huge ice crystals.
- Karaya foam stabilizes packaged whipped cream and other aerated dairy products.
- Karaya prevents syneresis and improves cheese spreadability. It stabilizes French salad dressings, sometimes with gum Arabic.
- Karaya with alginate or carrageenan prevents bread and other baked items from staling. This gum mixture made doughnut mixes more resistant to overmixing and better.
- Karaya's water-holding and binding characteristics make ground meat products like bologna smooth and appealing.

Gum Tragacanth

Gum tragacanth is the "dry gummy exudate" of *Astragalus gummiferLabillardiere*. Arabinogalactan and glycanogalactouronan comprise gum tragacanth.

Properties

Gum tragacanth expands in water to form thick, gel-like pastes. As gum content increases, viscosity rises sharply but decreases with shear rates in a typical pseudoplastic fashion. Tragacanth behaves like most gums—pseudoplastically. Even at very acidic pHs, tragacanth remains stable (pH 2). It is commonly utilized in culinary products like salad dressings that need stable viscosities at low pH. Gum tragacanth is an emulsifier because it rapidly lowers water's surface tension at low concentrations. Gum tragacanth is a good emulsifier due to its viscosity and acid stability. Gum tragacanth mixes well with most gum systems and adds viscosity. Gum Arabic decreases gum tragacanth's viscosity and generates smooth citrus oil, cod liver oil, linseed oil, and mineral oil emulsions. The choice of preservative for gum tragacanth-containing solutions depends on the formulation and finished product. Glycerol or propylene glycol preserves various emulsions.

Food Use

- Food uses gum tragacanth. It stabilizes ice cream, ice pops, water ice, chocolate milk drinks, puddings, and cheese.
- It's useful in bakery products (meringues, bakers' citrus oil emulsions, frozen pie fillings), dressings and sauces (salad dressing, syrups, and toppings, white sauces and gravies), beverages (soft drinks with fruit pulp, fruit juices and nectars, dry beverage mixes), confectionery products (candy gels and jellies, caramels, nougats, candy glaze, gum drops, jujubes, pastilles), and dietetic foods.

2.7 What is batter?

As the maker of many batters requires strong beating or whisking, the word "batter" derives from the old French verb "battre," which means "to beat." A batter is "a liquid mixture of water, flour, starch, and seasonings into which food items are dipped before cooking." Before frying, fish is frequently coated in batter in various regions of the world. For example, the batter is an essential component of the well-known British dish fish and chips.

a) Nature of the Coating

- A batter's viscosity can range from extremely "stiff" (sticking to an inverted spoon) to extremely "thin" (similar to single cream). Heat is typically supplied to the batter by frying, baking, or steaming to cook the contents (making them edible) and "set" the batter into a solid form. Typically, sugar or salt is added to either sweet or savory batters (sometimes both). Many other flavorings, such as herbs and vegetables, are added to the mixture to impart a distinctive flavor to the finished product.
- Now you will understand how to produce a batter-coated fish product. The fish cutlet is a classic example of a coated fish product that is commercially accessible. Fish meat that has been cooked and deboned is used as the primary ingredient for this cutlet. The cooked meat is thoroughly combined with cooked and mashed potatoes and seasonings before being formed into small, oval-shaped pieces. Before cooking, the pieces are coated with batter and then breadcrumbs. Here, you can see that roughly forty percent of the final product's ingredients are fish mince. The remaining components consist of starch (in the form of cooked potato) and coating (batter and breadcrumbs). Therefore, by coating the product with batter, we can increase its bulk value and impart the desired flavor.

b) Advantages of Coating

- Provides a crisp texture, an attractive color, and a good flavor.

- By incorporating nutrients into the coating, the nutritional value is improved.
- acts as a moisture barrier, preventing moisture loss during frozen storage and microwaving.
- performs the function of a food sealant by preventing the escape of natural fluids.
- provides the substrate with structural reinforcement.
- Increases the substrate's density, thereby decreasing the cost of the final product and leading to value addition, and leading to value addition.

2.7.1 Batter type

The two broad categories of batters are adhesive batter and tempura batter. Adhesive batters are traditional batters, also known as conventional batters. The adhesive batter is a fluid, primarily composed of flour and water, into which the item is dipped before cooking or frying. It functions as a layer of adhesion between the food substrate and subsequent breading. This batter's primary function is to improve crumb adhesion to the product. Generally speaking, the proportion of batter to water is 1:1. The desired viscosity and pick-up determine the ratio of the batter's components.

Tempura batters are also referred to as leavened or puff batters. Wheat and corn flour are crucial to this system. This batter forms a uniform, continuous, and crisp layer over the food as its final coating. Tempura batters produce coatings with an exceptionally high volume and a delicate texture. Figure 1.6 depicts tempura-coated shrimp that have been deep-fried. The tempura batters always contain leavening agents to produce leavening gas (carbon dioxide), so they are applied with special tempura batter applicators to preserve the leavening effect.

2.7.2 Role of batter ingredients

As you have seen in earlier sections, batter consists of a variety of components. The function that batter must fulfill in a coated product determines its composition. Each component of the batter will serve a specific purpose that contributes to the distinctive qualities and functioning of the coatings. In this section, you will learn about the essential classes of batter ingredients and their respective purposes.

The common elements of batter can be classified into seven groups or classes: polysaccharides, proteins, fats/hydrogenated oils, seasonings, leavening agents, gums, and the medium for mixing. Table 13 outlines the primary constituents within these categories of ingredients and their function in the product.

Table 13: Ingredients of Batter and Their Functions

Class of Ingredients	Components	Function in the Product
Polysaccharides	Wheat flour, corn flour, starch, and gums	Improves viscosity, emulsifying and foaming capacity, texture, and shelf life of the product
Proteins	Milk powder, milk proteinfraction, egg albumin, seed protein	Improve the water absorption capacity of the flour and thus increase the viscosity of the system
Fat/hydrogenated oils	Triglycerides, fatty acids	Texture, flavor imparting
Seasonings	Sugar, salt, spices	Enhance plasticizing effect, and flavor and impart antioxidant and antimicrobial properties
Leavening agents	Sodium bicarbonate, tartaric acid	Release carbondioxide in tempura batters
Gums	Xanthan, gum Arabic	Impart viscosity and enhance water binding capacity
Mixing Medium	Water	Provide gelatinization of starch, hydration of proteins, and Improves batter viscosity

2.7.3 Formulation in batter

Note that there are no exact recipes for the batter system. Depending on the food substrate and the intended appearance of the coating, formulations can be quite adaptable to allow for the maximum development of coated items.

However, you can categorize the batter's elements as essential or optional based on their purposes. The common compositions of batter systems with required and optional additives are presented in Table 14. The addition ranges listed are relatively broad, allowing for formulation flexibility to fit the final product.

Table 14: Ingredients for Batter Formulation

Ingredient	**Addition Range (%)**
Critical	
Wheat Flour	30-50
Corn flour	30-50
Sodium bicarbonate	Up to 3
Acid phosphate	Adjust, based on the neutralizing value
Optional	
Flours from rice, soy, barley	0-5
Oil	0-10
Dairy powders	0-3
Starches	0-5
Gums, emulsifiers, colors	< 1
Salt	Up to 5
Sugars	0-3
Flavorings/seasonings	Depends on taste, flavor

2.7.4 Factors responsible for the formulation of batter

Numerous variables influence the formulation of the batter. However, just a few are covered in the following section:

a) Corn in coatings

In batters and breading, corn performs various crucial roles. The most significant one is coloring the covering. Yellow corn's carotene content provides a natural source of color. Yellow maize, when combined with lowering sugars in batter mixes, produces an extremely appealing golden-brown surface color.

Yellow or white corn might be used, depending on the desired look. Corn is frequently used as a carrier in spice mixtures. The maize flour also helps to reduce the starchy flavor associated with coating systems containing a high concentration of wheat flour and/or starch. In batters, the interaction between corn and wheat flour affects the structure and texture of batter coatings. Adding or increasing maize will often boost crispness and decrease airiness in batter systems. Viscosity is one of the most essential characteristics of maize flour for batter mix manufacturers and consumers. Corn flour, not wheat flour, has traditionally been used to regulate the viscosity of batter systems.

b) Viscosity

You should recognize that viscosity is the most important rheological property in batter formulations, given that batter is applied to a liquid product. The performance of the batter during frying and the quality of the final product is determined by its viscosity. The viscosity influences the adhesion and adhering quality of the batter, as well as its handling capabilities, appearance, and ultimate texture. The rheological qualities of a batter are affected by the composition and proportion of its constituents. The addition of thickeners or proteins complicates the batter's flow characteristics. During the process of reconstituting the batter with water, care must be taken to incorporate the correct amount of liquid. Too much water might make the batter thin. During frying, a thin batter releases a great deal of water and generates a porous layer that absorbs a great deal of oil. Inadequate water might cause a thick batter. A thick layer of batter can result in an undercooked final product, a lack of crispness, and a generally lumpy, hard appearance.

c) Temperature

Keep in mind that temperature plays a crucial role in the reconstitution of batter as it impacts the viscosity of the batter. Once reconstituted, it must be stored at a low enough temperature to preserve its viscosity and prevent the growth of microorganisms. However, extremely low temperatures should be avoided, as they will cause the batter on the conveyor line to freeze. The recommended water temperature for batter reconstitution is between 10 and 15 degrees Celsius. Below 10 °C, the viscosity of water could become too high, preventing proper handling, whereas, beyond 18 °C, the viscosity could become too low.

d) Other Critical Coating Factors

1) Several general aspects must be considered for a coated product to be accepted by consumers. Coating media, such as batter and breadcrumbs, play a significant role in the retention of these properties in the product's final, ready-to-consume form. Several examples are as follows:

2) Appearance: This aspect considers the coated product's softness, hardness, thickness, texture, and transparency. The amount and homogeneity of the coating adhering to the product have a significant impact on these attributes. A thicker coating can result in a product with no texture, whereas a thinner, less viscous coating will allow air bubbles to form on the product's surface, creating an appealing texture.

3) Color: The color of the coated product can be determined by the cooking process, the medium employed, the condition of the frying oil, the batter's ingredient composition, and the choice of breading.

4) Crispiness is among the most essential coating properties. A lack of crispness can make chewing difficult or excessively soft. Ideally, the coating should have a structure that is sufficiently resistant to the initial bite but eventually dissolves in the mouth.

5) Adherence: The batter and breading employed in the coating must maintain uniform adhesion to the food substrate under varying processing circumstances. Poor adherence will result in economic loss in the form of dislodged batter fragments and an undesirable product

appearance.

6) A good coating system should be able to preserve the flavor of the coated product in its ready-to-eat state. Additionally, it should be able to seal or absorb the juices that would otherwise evaporate while cooking.

2.7.5 Variable affecting batter quality

Numerous variables affect battering quality, including the following:

- Effect of substrate quality on coating adhesion: Water content can directly affect the adherence of the batter. Excessive water content causes an "ice glaze" on the fish parts, resulting in inadequate batter adhesion. This will cause a problem known as "blow off," in which the batter will leave the surface of the fish when it enters the frying oil. Phosphates added to fish blocks will lengthen the cooking time of the Batter 13 product. This will result in batters that are darker and overdone, which may diminish the product's appeal to consumers.
- Effect of mixing on coating adhesion: If a prepared batter is not utilized, all dry ingredients must be well mixed to ensure optimal ingredient distribution. Before application, the batter should be hydrated (mixed with water) gently by adding a predetermined amount of water to a prescribed quantity of batter mix as the mixing operation continues. Continue mixing the batter until no dry lumps remain in the batter solution. A reduced hydration period results in a batter that is only partially hydrated, has a chewy texture and contains dry batter lumps.
- Effect of batter viscosity: The viscosity of the batter has a considerable impact on batter adherence and product encapsulation. The adhesive and encapsulating capabilities of a thick batter will be excellent. Typically, thin batters result in voids or blow-off issues.
- Effect of pre-dusting: The surface of the fish section is covered with dry cereal flour or the batter mixes itself, making it more receptive to

the adhesion of a wet batter. This is referred to as "pre-dusting." Typically, pre-dusting is performed on frozen pieces. The melting of the ice glaze can hydrate the pre-dust and improve the wet batter's adherence.

- Effect of Pre-Frying (Flash-Frying): The primary objective of Pre-Frying is to establish the breading or batter on the fish piece. Pre-frying also develops product color, forms a crust that is characteristic of fried foods, and imparts a fried appearance to the product, which inhibits freeze dehydration and contributes to flavor. This process is called pre-frying because the final product will be fried for approximately 4-5 minutes at the time of consumption, depending on the size and thickness of the coated portions.
- Effects of frying oil: Frying oil can affect the adhesion of the batter and the look of the final product. Extra batter in frying oil can cause oil degradation by darkening the oil and diminishing its quality. Reusing oil for frying is also not recommended for coated products.The pre-fried portion has a coating temperature equivalent to that of the frying oil, but the core temperature remains frozen as a result of handling. This temperature difference can cause food coatings to become unstable and susceptible to physical damage. To stabilize the batter coating, a cooling period should be allowed between frying and freezing. Due to the fragile nature of the coatings, care must be taken to prevent portions from coming into contact during the freezing process.

SUMMARY

Sugars are a type of simple carbohydrate (or monosaccharides). In this section, you learned that sugars' principal role in the food sector is to add sweetness to products. Sugars are used for many different things in the food industry as well. Sugars play a pivotal role in the non-enzymatic browning process, which can be favorable in some food items (especially bakery items) and undesirable in others. You already know that monosaccharide units are the building blocks of polysaccharides, which are complex carbohydrates made of linear or branched links. Carbohydrates and fiber make up the bulk of their makeup. Dietary polysaccharides include microbial polysaccharides and algal polysaccharides in addition to exudate gums and seed gums. Starches, we discovered, are the primary food supply for many organisms, including humans. There are amylose molecules (20-30%) and amylopectin molecules (the rest) (70-80 percent). They serve many purposes, including but not limited to adhering, binding, clouding, dusting, film forming, foam strengthening, getting, glazing, holding moisture, stabilizing texture, and thickening. Although starches can be used for a broad variety of purposes, they also have a few downsides. To get around these issues and expand starch's range of possible uses, modified starches are developed. Modified starches are used in the food and candy industries to make quick treats, salad dressings, toppings, etc. Food items are dipped into a batter, which is a liquid mixture of water, flour, starch, and seasonings, before being cooked. Sugar or salt is added to sweet or savory batters, and the batter is cooked by frying,

baking, or steaming. Use as the main component in making a batter-coated food item. The coating adds crunch, color, and flavor while also serving as a moisture barrier that keeps the food moist during freezing and microwaving. In addition to adding value by cutting production costs and increasing the substrate's density, structural strengthening is another benefit. A batter acts as an adhesive coating before the item is breaded. Polysaccharides, proteins, fats/hydrogenated oils, spices, leavening agents, gums, and a mixing medium make up the rest of the ingredients.

Progress Excercise

1. What is Maillard reaction and caramelization process?
2. Explain the following term:
    a. Weeping
    b. Amadori Reaction
3. Carbohydrates are classified into how many gropus?
4. Name of two major sources of carbohydrates.
5. What is Fibre?
6. Explain the term resistant starch.
7. Honey is better than sugars in confectionery industry why?
8. Discuss the role of sugars in preparation of dough and batters
9. Function of sugar in the baking of cakes?
10. Surface cracking in cookies is due to?
11. Discuss some applications of starches in the food industry
12. Explain the term retrogradation and gelatinization.
13. What is modified starch?
14. Explain about mentioned terms:
15. Oxidized starch
16. Starch acetates
17. Hydroxypropyl
18. NSP
19. Food hydrocolloids

20. Discuss the functional properties of gums which are used in
21. food industries?
22. What is the difference between cellulose and starch
23. Carrageenan is which type of polymer?
24. Give the name of three major types of carrageenan.
25. What is the food applications of the following:
    (a) Agar
    (b) Alginate
26. What is the seed gums?
27. Food applications of Locust bean gum and Guar gum
28. Explain the applications of the following terms
    (a) Gum Arabic
    (b) Gum karaya
    (c) Gum tragacanth

BLOCK INTRODUCTION

In this block we explained in detail about the Cereals, legumes, and animal feeds, fruits and vegetables, treatment, and other plants are processed to produce their starch for human consumption, animal feed, or industrial usage.

In unit 3 we will study about the cereal grains have been a staple of the human diet for millennia. Their processing is critical to food production, but it is difficult. The most common grain processes are dry milling (wheat and rye), pearling (rice, oat, and barley), wet milling (corn and wheat), and malting (barley, maize, and wheat). The physical and chemical qualities of grain processing byproducts vary. Because cereals are a major source of carbohydrates, proteins, lipids, vitamins, particularly B-complex and vitamin E, as well as inorganic and trace elements, reusing and valuing their byproducts is a major challenge for the sustainable development of the agrofood sector.

In unit 4 we will study about Fruits and vegetables are the most perishable commodities and are essential components of human diets. Fruits and vegetables are seasonal in nature, and prices fall significantly during the glut period, making production uneconomical owing to distressed sales. Thus, an increase in fruit and vegetable production has little value if the produce is not properly handled, processed, or utilized. Because the costs of loss prevention are always lower than the costs of production, processing has received increased attention in recent years.

India's fruit and vegetable processing business is severely disorganized. Fruit pulps and juice, fruit-based ready-to-serve drinks, canned fruits and vegetables, jams, squashes, pickles, chutneys, dried veggies, and so on are popular commercial goods. More recently, the sector has taken up manufacturing of frozen pulps and vegetables, frozen dried fruits and vegetables, fruit juice concentrates and vegetable curries in resealable pouches, canned mushroom and mushroom products. Preservation effects are complicated in real-world conditions, including approaches such as physical, physicochemical, chemical, and biological phenomena, and these phenomena never function in isolation. The paragraphs that follow discuss various well-established procedures for preserving fruits and vegetables, as well as the equipment needed and other specifics for a fruit and vegetable processing operation.

UNIT III: PROCESSING OF CEREALS, LEGUMES AND ANIMAL FOODS PREPARATION OF GLUTEN

STRUCTURE

Structure

3.1 Introduction

3.2 Protein

3.2.1 Classification

3.2.2 Composition

3.2.3 Functions

3.2.4 Sources

3.2.5 Functional properties

3.2.5.1 Hydration
3.2.5.2 Viscosity
3.2.5.3 Gelation
3.2.5.4 Texturization
3.2.5.5 DoughFormation
3.2.5.6 Emulsifying and Surface
3.2.5.7 Foaming
3.2.5.8 Binding

3.3 Effect of cooking and processing on plant food

3.3.1 Fruits andVegetables

3.3.2 Nuts/ Oil seeds andSpices.

3.3.3 Cereal Products andLegumes

3.4 Effect of cooking and processing on animal food

3.4.1 Milk and MilkProducts

3.4.2 Meat andPoultry

3.4.3 Fish

3.4.4 Egg

3.1 INTRODUCTION

During the second unit of the first block in this course, the primary components, specifically carbohydrates, and their physico-chemical properties were discussed. We have obtained comprehensive information regarding the composition and prevalence of these substances in their unprocessed state within food, as well as their practical implementation within the food manufacturing sector. It is well-known that food is a perishable commodity that is subject to a range of physical, chemical, and microbial transformations that may be deemed unfavorable. Therefore, to mitigate these alterations and guarantee its perpetual utilization and accessibility throughout the year, it is imperative to employ scientific methodologies for its processing and storage. The focus of this unit will be on the modifications that take place in the components of food as a result of processing and storage. The comprehension of the chemical composition and physicochemical properties of food, as acquired in previous units, can be applied to the interpretation of alterations that take place during processing and storage. Proteins, akin to carbohydrates and fats, are indispensable to human beings in a diverse range of manners. Proteins are intricate macromolecules that comprise at least 50% of the dehydrated mass of living cells. Proteinaceous materials such as muscle, ligament, cartilage, skin, and hair comprise a significant portion of biological tissues. Proteins are complex macromolecules that are composed of amino acids and play a crucial role in various biological processes. What are the composition, properties, and functional applications of food components? The aforementioned topics are deliberated upon within the confines of this module. The focus of this unit will be on the modifications that take place in the components of food as a result of processing and storage. The comprehension of the chemical makeup and physicochemical characteristics of food acquired in preceding units can be applied to the interpretation of alterations that take place during processing and preservation. The structural and functional characteristics of cells and organelles are governed by food components, primarily proteins. People should be aware of the categorization, function, and processing modifications of proteins due to their significance in daily nutritional needs. In the current context, food processing is crucial for achieving food security and providing people with safe food. There are benefits associated with food processing, some of which are major:

- Extended shelf life
- Reduced dangers from microbiological pathogen
- Reduced spoilage (microbial, enzymatic)
- Deactivation of anti-nutritional elements
- Guaranteed year-round availability of seasonal foods.
- Perishable goods were delivered to distant locations from their productionsite.
- Increased accessibility to comfort (e.g., Ready-to-serve beverages, instant mixes)
- Increased range of meals, including those with enhanced sensory and nutritional characteristics.

These ideas emphasize the significance of protein and food processing. As a result of the processing of cereal, legumes, and animal food and its constituents,positive changes occur, such as the production of pleasant colors and tastes, the improvement of texture, and the enhancement of the usefulness of foods or components. Nevertheless, a variety of unwanted changes can occur during food processing, which are often product- and process-specific, such as harm to color and flavor, damage to nutritional characteristics, and/or the creation of hazardous ingredients, etc.To obtain a healthy food product, it is required to optimize the process parameters based on the obtained knowledge of the numerous physical, chemical, and nutritional changes that may occur during food processing. This unit provides a detailed study of the functioning of proteins and the changes that occur in various meals during processing.

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

- Discuss the structure and categorization of proteins.
- List the characteristics of amino acids and proteins,
- Understand the uses for protein concentrates, isolates, and hydrolysates.
- Determine the changes in food undergoes. different methods of processing.
- Distinguish between favorable and unfavorable processing and storage processes in distinct food class.
- Consider the optimization of process parameters to govern chemical, physical, and nutritional changes in accordance with the requirements.
- Functional involvement in cell and organelle maintenance.

3.2 PROTEINS

Proteins, as you may already know, consist of carbon, hydrogen, nitrogen, oxygen, and typically Sulphur. Many amino acid molecules are linked via peptide bonds to form proteins. Every amino acid has a trivial or common name, which frequently relates to the source from which it was initially isolated (Table 1).

Table 1 Common name and source of some protein

NameofProtein	Source
Asparagine	Asparagus
Glutamine	Tyrosine
Wheat gluten	Cheese (*Tyros* is the *Greek word for cheese)*
Glycine*)*	sweet taste (*Glykos* is the *Greek word for sweet)*

Amino acids are twenty in number and classified according to the nature of the side chain (R group). We shall not go into the classification and composition of amino acids here.

3.2.1 Classification

Classification of proteins are discussed in table 2:

Table 2 Classification of protein

Shape and size	Functional properties	Solubility and physical properties
• Examples of fibrous proteins include keratin in hair, actin and myosin in muscle, and collagen. • Globular proteins, such as enzymes and antibodies, are spherical.	• Immunoproteins, include C-reactive protein, opsonin immunoglobulins, contractile respiratory, structural, enzymatic, and hormonal carrier proteins.	• Simpleproteins • Derivedproteins • Conjugatedproteins

As shown in table 2, proteins can be categorized according to:

a) *Size and structure:* fibrous and globular proteins. In organisms, fibrous proteins have structural roles. Globular proteins are composed of lengthy amino acid chains folded into intricate structures.

b) *Functional properties:* Immune, contractile, respiratory, structural, enzymatic, hormonal, and transporter proteins

c) *Solubility and material characteristics:* Proteins that are simple, conjugated, and derived. This categorization is provided in Table 3.

Table 3: Classification of proteins according to their solubility and physical character

Simple Proteins	Derived Proteins	Conjugated Proteins

Simple proteins mainly consist of amino acid units connected by a peptide link. They release a combination of amino acids and nothing else upon hydrolysis. *For examples*: *Albumins are egg albumin, serum albumin, Lactalbumin.* *Globulins are tissue globulin, serum globulin.* *Gliadins are gliadin from wheat, hordein (barley), etc.* *Albuminoids are keratin of hairs, skin, eggshell, and bones, elastin, and collagen of tendons, ligaments, and bones.* *Histones are globin of the hemoglobin,* *Protamine are salmine is the spermatozoa of the salmon fish.*	These proteins are not found in nature and are generated from simple proteins by the action of enzymes and chemical agents, heat, mechanical shaking, ultraviolet light, or x-rays. *For examples:* Primary: Myosin, Fibrin, and Secondary: Peptones, peptides, proteoses etc.	Simple proteins are joined with a non-protein material to form conjugated proteins. The chemical is referred to as a prosthetic group or cofactor. *For examples:* *Chromoproteins:* Hemoglobin, in which the prosthetic group is iron. *Phosphoproteins*: casein in milk, in which prosthetic group is phosphoric acid, vitellin in eggyolk. *Lipoproteins:* HDL (high density lipoprotein), LDL (low density lipoprotein) and VLDL (very low-density lipoproteins), the prosthetic group islipid *Glycoprotein*: Ovomucoid of egg white. *Nucleoproteins:* ribosomes andviruses. *Metalloproteins:* alcohol dehydrogenase, a Zn containingenzyme. *Mucoproteins:* Follicle stimulating hormone,β-ovomucoid.

3.2.2 Composition

Amino acids are the fundamental components of proteins. A peptide bond is created between amino acids by the removal of a water molecule. Considering the length of peptide chains and the structural diversity of twenty amino acids, the protein structure is separated into four distinct levels, as shown in Table 4.

Table 4Different levels of protein structure

Primary structure	The fundamental structure of a protein consists of the order in which amino acids are peptide-bonded to one another.
Secondary structure	The secondary structure of a protein consists of the manner in which the chain of amino acids twists or folds back over itself to produce alpha helical, beta sheet, or a number of other potential configurations.
Tertiary structure	The secondary structure, in turn, folds back and forms three dimensional linkages with itself.

Quaternary structure	When a protein is composed of several chains, or the structure in which these chains bind together.

3.2.3 Functions

The structural and functional characteristics of cells and organelles include proteins. Proteins can be categorized using the following scheme:

A. Structural elements: Proteins that make up structural molecules are fibrous. Keratins, the most well-known fibrous proteins, constitute the protective covering of all terrestrial vertebrates: skin, fur, hair, wool, claws, nails, hooves, horns, scales, beaks, and feathers. The actin and myosin proteins of muscle tissue are equally pervasive, but less apparent. Support is highly dependent on structural proteins. Collagen and elastin provide a fibrous framework for animal connective tissues, such as tendons and ligaments, which are composed of collagen and elastin.

B. Defensive Proteins: These proteins provide disease protection. Antibodies are a type of protective protein. These battle viruses and germs. Furthermore, immunoglobulins, as you already know, protect the body against invading organisms and illnesses.

C. Contractile Proteins: These proteins are involved in contractile activities, such as those seen in muscle proteins and other cells and tissues. In the latter, these proteins are involved in cytoplasmic localized contractile events, motile activity, and cell aggregation processes. Contractile proteins include actin, myosin, myoglobin, and troponin, among others. Actin and myosin are responsible for muscular contractions. Numerous cells are propelled by the undulations of cilia and flagella, which are caused by contractile proteins.

D. Essential and Storage Proteins: These proteins are capable of storing amino acids. Ovalbumin is the egg white protein used by the developing embryo as a source of amino acids. Casein, the milk protein, is the most important supply of amino acids for infant mammals. Plants store proteins in seeds.

E. Transport of plasma proteins: Embedded in lipid membranes, transport proteins assist the import of nutrients into cells or the discharge of hazardous byproducts into the surrounding medium. Transport proteins are required for the passage of molecules that cannot move across a membrane by diffusion. These attach to tiny molecules and ions and carry them throughout the body as plasma carriers. Several popular instances include:

- Transferrin, an iron-binding protein, transports ferrous ions to hemoglobin producing loci.
- The ratio of free to bound species regulates the activity of ions, such as calcium.
- When hydrogen ions are bound, proteins serve as buffers to reduce the pH shift.
- Since cells are impermeable to proteins, they also contribute to the determination of ion distribution and, consequently, electrical potential difference across the cell membrane.
- Albumins mediate the distribution of bodily fluids between plasma and extracellular compartments by virtue of their osmotic action.

F. Enzymatic Proteins: The proteins with catalytic activity - the enzymes - are the most diverse and most specialized. Almost all chemical processes of organic biomolecules in cells are catalyzed by enzymes, as you may be aware. There are more than 2,000 recognized enzymes. Mechanochemical enzymes, such as actin, myosin, and associated proteins of the muscle structure, are responsible for the transformation of chemical energy into mechanical work.

G. Hormonal proteins: Hormonal proteins regulate biological functions. Diverse peptide and protein hormones (including insulin and growth hormone) contain information that affects the permeability and metabolism of cells. Built inside the membrane of a nerve cell, receptor proteins detect chemical signals emitted by other nerve cells. The response of a cell to chemical stimuli is mediated by receptor proteins.

H. Miscellaneous Functions: In addition to the functions listed above, this section also includes a number of significant miscellaneous functions of proteins. These consist of:

- Source of vitality: Amino acids are capable of being deaminated and converted to carbon dioxide and water.
- Toxic proteins (for humans - botulinum toxin, staphylococcal toxin, venom toxin; for microorganisms - antibiotics)
- Anti-nutritional factors (trypsin inhibitors).
- Numerous allergic responses to food are also mediated by proteins, resulting in a change of the consumer's defense mechanism due to the presence of proteinaceous antigens in meals that stimulate antibody formation.
- Intense sweeteners (Monellin).

3.2.4 Sources

There are three primary types of protein-containing foods:

I. Origin of Animal Protein
II. Protein from Plant Source
III. Single cell protein

Detail all food sources are as follows:

1. **Origin of animal proteins**

The animal-based foods arecategorized as protein-rich sources. Although you may already be aware of these sources, we have included them here for your consideration.For feeding purposes, skeletal or striated muscles are utilized.

4 **Meat:**The majority of the meat composition consists of beef, lamb, and

swine. These are referred to as "Red Flesh," a word describing the hues of beef, lamb, and pork as contrasted to the pale anddark colors of poultry meat. Myoglobin is mostly responsible for the red hue.On a wet weight basis, a normal adult mammalian muscle devoid of all external fat comprises between 18 and 22 % protein. On the basis of their origin and solubility, muscle proteins can be classified as sarcoplasmic, contractile (myofibrillar), or stroma (connective tissue) proteins.

5 **Milk:**Typically, a protein content of 3.5 % is regarded to be ordinary for milk. Casein and whey proteins have typically been used to classify milk protein. Casein is a heterogeneous set of phosphoproteins that may be precipitated from raw skim milk at pH 4.6 and 20^{0}C by acidification. Whey proteins are the proteins left in solution following casein precipitation (or milk serum proteins). Casein fraction accounts for approximately 80% of the overall protein composition; whey protein makes up theremainder.Whey fraction consists mostly of -lactalbumin, -lactalbumin,immunoglobulins,bovine serum albumin, and so on.

6 **Eggs:** The composition of a chicken egg is around 11% shell, 31% yolk, and 58% white. 65 % of a liquid whole egg is white and 35 % is yolk. The major purpose of egg protein is to nourish and sustain the developing chick. Yolk appears to be the primary source of nutrition, whereas egg white appears to serve as a barrier before being used as a source of protein. White and yolk vary fundamentally in their makeup.Yolk: The yolk includes around 50% solids, of which two-thirds are lipids and proteins. On a dry-weight basis, the egg yolk comprises 31% fat, of which 1.3% is cholesterol.Essentially, white is an aqueous solution containing around 12 % protein.The edible element of a fish is its skeletal muscles. Despite the fact that the skeletal muscles of various animals are fundamentally identical, the variety of edible fish species is far greater than that of mammalian species.

7 **Fish:** Itcomprise between 40 and 60 % edible meat. 13 to 25 % of freshwater fish are composed of protein. In the midline or lateral line of many fishes, there is a layer of strongly pigmented, reddish-brown muscle that may account for 10 % of the total body muscle. This includes a high concentration of hemoprotein, which, after harvest, may accelerate lipid oxidation and induce significant rancidity. The proteins can be categorized as either sarcoplasmic, myofibrillar, or connective tissue proteins.Information about shellfish is sparse and insufficient. In shellfish, the shell constitutes a significant amount of the fish's live weight, resulting in a low edible content. Shellfish examples include crabs, lobsters, shrimp, and muscle oysters, etc.

2. **Proteins derived from plants.**

The origin of vegetable proteins, cereal proteins, nut and seed proteins is the plant kingdom. Let us investigate these sources further.

1) **Vegetable Proteins:** Fresh veggies are not a very reliable source of protein. Carrots and lettuce have an average protein value of 1 %, whereas white potatoes, asparagus, and green beans have an average protein content of 2 %, and fresh peas have an average protein content of 6 %.Even though potatoes contain only 2 % protein, their quality is rated as acceptable to outstanding due to their comparatively high lysine and tryptophan levels. The majority of tuber proteins are located in the outer layers, or "cortex." These layers contain significantly more necessary amino acids than the inner layers. Selective plant breeding can enhance the outer layer proteins.

2) **Cereal Protein:** Cereal grains that have been adequately ripened and dried for optimal storage stability contain between 6 and 20 % protein. Proteins are present in a variety of grain morphological tissues. In the milling of grain (such as wheat), the endosperm is effectively separated from the bran and germ before being ground into flour, which is

subsequently consumed as food. Endosperm proteins appear to serve as both structural components and feeding stores for seedlings. The sub-cellular granules or organelles known as 'protein bodies' house a significant portion of the endosperm storage proteins in the kernel of numerous cereals (except in wheat kernel).The protein of the bran or seed coat supplies the kernel with shape and protection. Since bran is poorly digested by humans and its proteins are difficult to isolate, the majority of it is utilized as animal feed.

3) **Seed Proteins:** Although a vast variety of plants generate seeds with protein concentrations greater than 15 %, only a few are used as food, such as soybeans, cotton seeds, peas, peanuts, and beans. Proteins in seeds are concentrated mostly in protein bodies. These bodies, which contain more than 90 % protein, contribute for 70 % of soybeans' overall protein content.Proteins make up a substantial amount of food reserves, which are crucial during germination. The proteins of the majority of seeds (excluding grains) are globulins, which are water- or salt-soluble.

4) **Nuts protein:** Nuts are an exceptional source of protein. Nuts include cashews, almonds, hazelnuts, coconuts, walnuts, Brazil nuts, cashews, and pistachios, among others. Almonds and other nuts have full proteins. Those nuts that do not contain complete proteins can be incredibly valuable sources of protein when consumed with other protein-containing meals, milk, cheese, or vegetables.After studying proteins derived from plants, we will go on to studying proteins derived from microorganisms.

3. **Single Cell Proteins (SCP)**

You may be familiar with SCP. What is a cellular protein? Let's find out. Prof. Caroll Wilson (MIT) invented the term SCP in 1966. It refers to the proteins derived from microorganisms, such as algae, fungus, bacteria, and yeast.

From bacteria, proteins are extracted. Following are some of the benefits of selecting microbes as a protein source:

3 High protein yield on a dry weight basis.

4 Nutritional need is cost effective.

5 The installation of plants for the synthesis of proteins requires less space than traditional sources.

6 The facility may be constructed so that continuous processing is possible, as opposed to batch-by-batch processing.

For single cell proteins, bacteria, yeast, fungi and algae may be used. Each of them has their own advantages and disadvantages. These have been highlighted in Table 5. Another interesting aspect which you would surely like to know about is how these single cell proteins are manufactured. This is some additional information for your knowledge.

Table 5: Advantages and disadvantages of using microorganisms as a source of protein.

➢ **Organisms**	➢ **Advantages**	➢ **Disadvantages**
➢ Bacteria	➢ High protein content (60- 80 %) ➢ Grown on paraffin, waste cellulose, and molasses. ➢ The growth rate is rapid.	➢ If the bacterial strain is very tiny and has a low density, it is difficult to separate it from the culture medium. ➢ Bacteria have a high nucleic acid content (more than 15 %) and may arrive with proteins, which is unacceptable and unnecessary since it can induce hypertension, arthritis, and other conditions. ➢ Uric acid, the end result of purine metabolism, may contribute to the development of gout.
➢ Yeast	➢ Large size, hence simple separation from the culture media. ➢ As the growth pH moves towards the acidic side, a high amount of lysine is created in the proteins, making them more palatable and of greater biological	➢ Reduced protein yield (45-60 %) ➢ Low pace of growth (1-3 h) ➢ High nucleic acid concentration leading to uric acid production.

	significance.	
➢ Fungi	➢ Easy to collect from the medium of cultivation. ➢ The cellular structure of fungus enhances the functional characteristics of proteins.	➢ Reduced protein yield (5-27 %). ➢ Low rate of growth. ➢ Proteins have low acceptance.
➢ Algae	➢ Produces proteins containing almost all Essential Amino Acids. ➢ Rich in tyrosine and serine but lacking in amino acids containing Sulphur.	➢ Due to the indigestible cellulose cell wall un humans, consuming more over 100 g of proteins might produce nausea, vomiting, and stomach discomfort, among other symptoms.

3.2.5 Functional properties

It may now be clear that functionality (as indicated to food items) refers to "any feature other than nutritional qualities that influences the usability of food components." The majority of functional features influence the sensory aspects (particularly textural attributes) of foods, but they can also have a significant impact on the physical behavior of food and food ingredients during preparation. Thus, the functional properties of proteins are the physicochemical features that allow the proteins to contribute to the desired qualities of the diet. Proteins may be added to diets for functional, nutritional, and economic reasons, as we have learned. Possible functional advantages include emulsification and stability, higher viscosity, enhanced appearance, flavor, or texture, formation of foams and gels, and binding of fat or water. These functional features enable the technician to adjust flow characteristics, emulsify, produce gels and foams, and bind water and fat. Dietary advantages include reducing the calorie number of meals, boosting the protein content, and balancing the amino acid balance. Obviously, economic or cost factors are also significant when employing protein as a component. Increased product yield due to the use of a protein addition is an illustration of an economic gain. It is also essential to understand that the origin of the protein (animal or plant) and its structure impact its functional qualities. Three categories of protein functional characteristics have been identified are as follows:

a. Hydration properties: It is dependent on protein-water interactions and include swelling, adhesion, dispersibility, solubility, and viscosity.

b. Protein-protein interactions: They are associated with the processes of precipitation, gelation, and creation of various structures (like protein doughs and fibers).

c. The surface properties: It pertain largely to their surface tension, emulsification, and foaming qualities.

A. Hydration Properties

Individual proteins' structure in solution is mostly determined by their interaction with water. Hydration of protein preparations is connected to several functional characteristics. Water absorption (water uptake, affinity, or binding), swelling, wettability, water holding capacity (water retention), as well as cohesion and adhesion, are associated with the first four steps (figure 4.2), whereas dispersibility and viscosity (or thickening power) are also associated with the fifth step. Important functional qualities, such as solubility or immediate solubility, are connected to the soluble or insoluble (partially or completely) final state of proteins (in which all five steps take place rapidly). Gelation refers to "the production of a well-hydrated, insoluble mass with specialized protein-protein interactions" In addition to its qualities, surface properties such as emulsification and foaming require a high level of protein hydration and dispersion. The hydration qualities, such as solubility, viscosity, are discussed below:

Protein Precipitation/Solubility

- The degree of protein solubility dictates the majority of their functional characteristics. The solubility behavior is an excellent indicator of the possible applications of proteins. This is because the degree of insolubility is likely the most applicable measure of protein denaturation and aggregation, and because proteins that initially exist in a denatured, partially aggregated state typically have a diminished capacity to effectively participate in gelation, emulsification, and foaming.

- Note that, in general, highly soluble proteins can be utilized in applications where emulsification, whipping, and film formation are crucial, whereas low solubility may be desirable in applications with high protein levels and where minimal emulsification, or protein-protein interactions are required.
- Heating significantly and permanently reduces the solubility of proteins. However, heat treatments may be required to accomplish other goals (microbial inactivation, removal of off-flavor, removal of water and others).
- It is not necessarily accurate to assume that proteins must have a high initial solubility as a precondition for other functional qualities. It has already been established that preliminary denaturation and partial in solubilization can occasionally boost the water absorption of a protein component. The creation of emulsions, foams, and gels can include varying degrees of protein unfolding, aggregation, and in solubilization.
- To be effective in emulsification, foams, and gels, whey proteins and some other proteins must have a relatively high initial solubility. Soluble caseinates are more effective in thickening and emulsifying than isoelectric casein (less soluble). Perhaps the greatest benefit of insolubility is that it allows for the quick and broad dispersion of protein molecules and particles, resulting in a colloidal system with a homogenous macroscopic structure and a smooth texture. Additionally, initial solubility enhances diffusion of proteins to the air/water and oil/water interfaces, therefore enhancing their surface activity.

- *Texture, viscosity, and gelation*

- The apparent diameter of the distributed molecule has the greatest influence on the viscosity performance of protein fluids, which is based on the following parameters:
- The intrinsic properties of a protein molecule (molar mass, size, volume, structure and asymmetry, electric charges, and ease of deformation) can be modified by environmental factors such as pH, ionic strength, and temperature through unfolding; Protein solvent interaction, which affects swelling, solubility, and the hydrodynamic sphere surrounding the molecule; and Protein-protein interactions, which determine aggregates. Typically, a high quantity of protein components is employed, with protein-protein interactions predominating.
- Fluid meals, such as drinks, soups, sauces, and creams, rely heavily on the viscosity and consistency of protein systems for their functionality. There is no straightforward correlation between viscosity and solubility. When put in an aqueous solution, heat-denatured protein powders that are insoluble do not have a viscosity that is too thick. Whey proteins are highly soluble protein powders with minimal water absorption and swelling capabilities, as well as low viscosity at neutral or pH. The viscosity of soluble protein powders with a high initial water absorption capacity (sodium caseinates and soy protein preparations) is high. Thus, there is a positive link between water absorption and viscosity for proteins.
- Gelation is the process through which denatured molecules assemble into an organized protein network. In food items, proteins can produce a well-ordered gel matrix by balancing protein-protein and protein-solvent interactions. These gel matrices can retain additional food components, such as gelatin, yoghurt, minced meat products, tofu, and bread doughs, for manufacturing food items.

- Gelation is an important functional property of proteins that plays a crucial role in the preparation of numerous foods, such as various dairy products, coagulated egg whites, gelatin gels, various heated, ground meat or fish products, soybean protein gels, vegetable proteins texturized by extrusion or spinning, and bread doughs. Protein gelation is used not only for the creation of viscoelastic gels, but also for enhanced water and fat absorption, thickening, particle binding (adhesion), and emulsion or foam stabilization effect.
- It is essential, while investigating gelation, to distinguish it from other events in which the degree of dispersion of a protein solution decrease. Important key word description is also discussed here:

I. Association: relates to subunit or molecular level alterations.

II. Polymerization or aggregation is characterized by the creation of massive complexes.

III. Precipitation: covers all aggregation events that result in complete solubility loss.

IV. Flocculation is a random aggregation process that happens in the absence of denaturation and is frequently caused by the suppression of electrostatic repulsion between chains.

V. Coagulation is characterized by random aggregation accompanied by denaturation and aggregation processes in which protein-protein interactions prevail over protein-solvent interactions and result in the formation of a coarse coagulum.

- *Texturization*

- Proteins, whether derived from live tissue (myofibrils in meat or fish) or manufactured molecules, serve as the structural and textural foundation for several meals (bread dough and crumb, soy or gelatin gels, cheese, curds, sausage, meat emulsion etc.).

- In addition, there are a variety of texturization techniques that begin with soluble vegetable or milk proteins and result in film or fiber-like products with chewiness and strong water-holding capacity and the ability to preserve these features following hydration and heat treatment. These texturized proteins are frequently employed as alternatives for meat and/or as meat extenders. In addition, certain texturization procedures were used to retexturize or reform animal proteins, such as beef or chicken flesh. Presented below are the known physicochemical bases for several of these texturization processes:

- *Thermal Coagulation and Film Formation*

- Soy proteins may be thermally coagulated over a flat metallic surface, such as that of a drum dryer, to form a film. Thin, hydrated sheets that result can be folded, pushed together, and sliced.

- The production of vegetable (particularly soy) and milk proteins into fibers resembles the development of synthetic textile fibers in many ways. Typically, it is required to begin with isolates having at least 90 % protein. Four to five surgeries can be performed constantly in succession.

- Thermoplastic extrusion is now the most used method for producing vegetable proteins. Instead of fibers, thermoplastic extrusion produces dry fibrous and porous granules or chunks with a chewy feel upon rehydration. Therefore, less expensive protein concentrates or flours (containing 45-70 % protein) can be utilized in place of protein isolates. Casein or gluten can be introduced in their natural state. The addition of a modest quantity of starch or amylose improves the texture of the finished product, however a lipid content greater than 5-10 % is negative. Adding 3 % sodium chloride or calcium chloride also strengthens the consistency. Proteins with the suitable initial solubility, high molecular weight, and the formation of the proper plasticizing and viscous characteristics of the protein-polysaccharide combination within the dye are required for good texturization using this method.

B. *Properties related to protein-protein interactions.*

- As one of the most significant functional characteristics of proteins, dough forming is one of the qualities associated to protein-protein interactions. Let we investigate dough creation.
- Dough Structure: You are well aware that gluten is the wheat protein. When combined and kneaded in the presence of water at room temperature, gluten proteins of wheat grain endosperm (and to a lesser degree rye and barley grains) are able to produce a highly cohesive and viscoelastic mass or dough. Wheat flour includes, in addition to glutens (gliadin and glutenin), starch granules, pentosans, polar and non-polar lipids, and soluble proteins, all of which contribute to the creation of dough network and/or the final texture of bread.
- The composition and size of gliadins and glutenin explain the majority of gluten's behavior. Gluten proteins have limited solubility in neutral aqueous solutions due to their low concentration of ionizable amino acids. Rich in glutamine (>33 % by weight) and hydroxy amino acids, they are susceptible to hydrogen bonding, which is primarily responsible for gluten's water-absorbing ability and cohesion and adhesion capabilities. In addition, the presence of many polar amino acids and the resultant hydrophobic interactions lead to protein aggregation and the binding of lipids and glycoproteins. The capacity to create multiple -S-S cross-links explains the ease with which these proteins interlink tenaciously in dough.
- We have been kneading doughs for a long time without comprehending the inside mechanics. Modifications are made to gluten proteins during dough formation are discussed below:

Changes In Gluten Proteins During Dough Formation

Initial gluten formation occurs when flour and water are combined. Using water as a medium, the flour proteins glutenin and gliadin cross-link to generate gluten. Improving this gluten structure is essential for generating a bread/chapati structure that retains gas. When bread flour that has been moistened is combined and kneaded, the gluten proteins align and partially unfurl. This increases hydrophobic contact and disulphide bridge production via -S-S- exchange events. As the first gluten particles change into this membrane (film), they serve to entrap starch granules and other flour components inside a three-dimensional protein network. Cleavage of disulfide bridges by reducing agents such as cysteine degrades the cohesion of hydrated gluten and bread dough; the addition of agents such as bromates increases toughness and elasticity. Certain types of "strong" wheat flour demand a lengthy mixing time and produce dough with a high degree of cohesion. When the energy or length of mixing surpasses a specific threshold, "weak flours" are less effective and the gluten network breaks down, most likely due to the rupture of -S-S- links (especially in absence of air). The relationship between dough strength and a high concentration of glutenin with high molecular weight, including completely insoluble "residue proteins," appears to exist. Experiments with "reconstituted" wheat flours of varying gliadin and glutenin ratios suggest that glutenin are responsible for the elasticity, cohesiveness, and mixing tolerance of dough, whereas gliadins contribute to dough's fluidity, extensibility, and expansion, resulting in a larger bread loaf volume. A precise ratio of proteins is required for breadmaking. Excessive cohesiveness (glutenin) inhibits the growth of trapped CO_2 bubbles during fermentation, dough rise, and consequent presence of open-air cells in the bread crumb. Excessive extensibility (gliadins) results in weak and permeable gluten films; hence, CO_2 retention is poor and dough collapse may ensue.

C. Surface properties of proteins

The surface properties of proteins are essentially related to their surface tension, emulsification, and foaming capabilities, which are detailed below:

- Proteins are the surface-active proteins that are widely utilized as emulsifiers in the food business to produce desserts, spreads, and whipped cream.
- Emulsions Stabilized with Protein: Numerous food items (e.g., milk cream, ice creams, cream, butter, etc.) are emulsions, and protein contents frequently play a significant role in stabilizing these colloidal systems. Immunoglobulins are the soluble proteins present in fresh milk. Homogenization of milk improves emulsion stability because it lowers fat globule size and because newly produced casein submicelles displace immunoglobulins and adsorb to fat globules.
- Proteins maintain emulsions and provide physical and rheological qualities, such as thickness, viscosity, elasticity, and stiffness, which influence droplet coalescence resistance. Depending on the pH, ionization of amino acid side chains may also occur, providing electrostatic repulsive force that promotes emulsion stability. This functional feature is essential to the creation of several common food items, including salad dressings and sausages.
- Proteins are often poor water/oil (w/o) emulsion stabilizers. In unit 7 of this course, you will read extensively about emulsions. This may be due to the hydrophobic nature of most proteins, which causes the majority of an adsorbed protein molecule to dwell on the water side of the contact.
- Proteins have the ability to attach to water, lipids, volatile flavors, and other molecules, and they exhibit vital functional qualities.

Foaming Properties

- To comprehend the foaming capabilities of proteins, a fundamental understanding of foam foods is required. Typically, foam meals consist of a colloidal dispersion of gas bubbles in a continuous liquid or semisolid phase including a soluble surfactant. (Surfactant is a chemical substance that works as a surface modifier which decreases the surface tension of the liquid). Cakes, whipped creams and toppings, ice creams, etc., are examples of foods containing a wide range of protein-based food foams with varying textures. In many instances, the gas is air (sometimes CO_2), and the continuous phase is a protein-containing aqueous or suspension. In unit 7, you will learn more about foams.

- What are the fundamental features of proteins that make them effective foaming agents? A protein must be capable of quick absorption at the air-water interface during whipping, rapid organization and rearrangement at the interface, and the formation of a cohesive viscoelastic film.

Flavor Binding

- Some protein preparations, although being functionally and nutritionally acceptable, require a deodorizing procedure to eliminate binding off-flavors. Aldehydes, ketones, alcohols, and oxidized fatty acids can generate beany or rancid odors as well as bitter or astringent taste. When attached to proteins or other components, these chemicals are liberated and become noticeable when cooking and/or chewing. Some are so tightly bonded that neither steam nor solvent extraction can extract them.
- Unlike the challenge of removing undesirable flavors, it may be beneficial to employ proteins as transporters for good flavors. It is desirable to provide a meat-like taste to texturized vegetable proteins. Idealistically, all volatile flavor ingredients must stay bonded throughout storage, maybe also owing to processing, and then be rapidly and completely released in the mouth without distortion. The aforementioned problems can be resolved by studying the process by which volatile chemicals bind to proteins.

Protein Interactions with Volatile Substances

- Flavor binding may entail adsorption at the food's surface or diffusion into the food's core (absorption). We refer to adsorption as a surface phenomenon involving the adhesion of molecules of gases, dissolved chemicals, or liquids in more or less concentrated form to the surface of solids/liquids with which they come into contact.

- Adsorption-based flavor binding involves a physical or chemical adsorption process and hydrophobic contact. Hydrogen bonds bind polar molecules, such as alcohols, whereas hydrophobic interactions with nonpolar amino acids dominate the binding of low molecular weight volatile chemicals.
- In some instances, volatile chemicals form covalent bonds with proteins, a process that is often irreversible. High-molecular-weight volatiles are more susceptible to irreversible fixation.

Binding to Other Substances

- Depending on their chemical structure, dietary proteins can bind a variety of different molecules via weak interactions or covalent connections in addition to water, lipids, and volatile flavors. Examples include pigments, synthetic dyes (which may be utilized for protein analysis), and chemicals having mutagenic and sensitizing biological action. Such binding may result in an increase in toxicity or detoxification, and in certain instances, the nutritional value may be diminished.

3.3 Effect of cooking and processing on plant food

3.3.1 Fruits andvegetables

- You may already be aware that fruits and vegetables vary greatly in their chemical composition. However, some generalizations are possible. Fruits and vegetables have high water content, with a range from approximately 70 per cent for pears and bananas to 91 per cent for cabbage. The amount of protein and lipids in fruits and vegetables is usuallyverylow,thoughbotharegoodsourcesofvitaminsparticularlyvitamins Aand4C. Part of the carbohydrate in fresh fruits and vegetables is present as cellulose and pectic substances in the cell wall. Starch is present in almost all fruits and vegetables, although it may decrease on ripening. Glucose, fructose and sucrose are widely distributed whose content vary considerably in various fruits and vegetables. Further, we have also seen that carotenoid, chlorophylls, anthoxanthins and anthocyanins are the chief pigments present in fruits andvegetables.

- The detailed chemical changes that occur when fruits and vegetables are boiled in water or steamed, canned, dried or frozen, are still for the most part unknown. However, certain fruits and vegetables like apples, peaches, potato etc. turn brown when cut and exposed to air. This is a result of numerous enzymatic reactions that occur in fruit and vegetables on processing. These reactions may result in changes in the appearance, texture, flavor and color of the fruits and vegetables.
- Further, as a result of changes in the cell wall and intercellular structure, all fruits and vegetables undergo softening when cooked, no matter by what method. The changes occur in pectic substances, cellulose, starch and intercellular air. Cellulose, pectin and hemicellulose, as you have learnt earlier, are the major polysaccharide components in the cell wall of all plant foods. There has been a rapid progress in understanding the physical and chemical properties of polysaccharides in recent years. Studies on the role of cell wall components in food texture have been done, particularly on pectic substances. Alterations in pigments, formation of acids and release of low molecular weight sulfur compounds have been reported as the major changes during processing of fruits and vegetables. In a study, reactivation of a pectin esterase has been found in cucumber slices. When fresh cucumber slices were blanched for 3 minutes at 81o C, enzyme activity could not be detected. However, when the blanched slices were stored in a pH 3.7, brine containing 0.6% acetic acid, 2.5% sodium chloride (NaCl), and 200 ppm Sulphur dioxide (SO2), about 20% of the activity present in the fresh tissue was regained during the first month of storage.
- In processing fruits and vegetables, loss of carotenoids into cooking or canning water is very slight. However, carotenoids undergo oxidation when exposed to air, so that drying of fruits or vegetables which contain these pigments, a problem is sometimes encountered. For example, carrots and apricots show loss of pigment on drying. Antioxidants partially protect the pigment from deterioration, as it is reasoned that the

degradation of the pigment might be associated with the oxidative changes in the fat.

- Chlorophyll, the pigment responsible for giving bright green color to the vegetables, is very unstable and undergoes changes in color which are often considered to be undesirable. Have you ever noticed the color change in spinach when boiled in water? Yes, the green color of the spinach turns to olive green and then to brown when the leaves are cooked for long. Basically, chlorophyll changes to olive green color and then to brown when the food is heated, and the reaction is faster in acid solutions. When a vegetable becomes olive green on cooking, the chlorophyll gets converted to pheophytin (a derivative of chlorophyll) (Fig 1). The reaction can be written schematically as indicated below. Hence, special care must be taken to produce food products from plant sources to retain a bright, attractive green color.

$$\underset{\text{(Chlorophyll)}}{C_{32}H_{30}ON_4Mg\begin{cases} COOCH_3 \\ COOC_{20}H_{37} \end{cases}} + 2H^{+} \longrightarrow \underset{\text{(Pheophytin)}}{C_{32}H_{30}ON_4H_2\begin{cases} COOCH_3 \\ COOC_{20}H_{37} \end{cases}} + Mg^{++}$$

Fig 1 Effect of heating on chlorophyll

- Dehydration is one of the oldest food preparation methods. Dehydration is the process of removing all water from a food item under controlled conditions such that little changes occur. We shall study the approach in Unit 11 later. Here, we will examine the changes that occur in fruits and vegetables during dehydration. Vegetable dehydration decreases the natural water content below the crucial threshold for the development of germs (12 to 15 %) without compromising essential nutrients. Additionally, it aims to preserve flavor, scent, and appearance, as well as the capacity to recover original form or appearance upon reconstitution with water. However, the process of dehydration is also accompanied by considerable changes. These consist of:
- First, there is a concentration of important components, including proteins, carbs, and minerals. This is accompanied by chemical changes.

Although fats are found in small quantities in vegetables, oxidation frequently reduces their aroma and flavor. In a Maillard reaction (you may recall reading about it in Unit 2), amino compounds and carbohydrates interact, resulting in a darker color and the formation of new scent molecules. Vitamin levels may also rapidly decline. Depending on the intensity of the processing conditions, the original volatile fragrance and flavor components are lost in large quantities during processing.

- Dried fruits are extraordinarily calorically dense and a considerable source of nutrients. Among the vitamins contained in fruits, only Carotene and the B-group vitamins remain unaffected. Vitamin C is lost in considerable quantity. Vitamin B1 is destroyed by sulfite treatment, however fruit color and vitamin C can be preserved and maintained.
- Freezing is another old food processing method that enables the long-distance transit of perishable food products from production to consumption centers. Freezing is the process of maintaining the available water in a food or food product at or below -18°C. Vegetables are often frozen using traditional freezing procedures including indirect cold transfer in plate or air freezers. We will study more about freezing in Unit 11, but for now we will examine the changes that occur in fruits and vegetables as a result of the freezing processing method.
- Vegetables and nutrients are preserved by freezing to a large extent. Spinach, peas, and beans retain vitamin A and -carotene well, but asparagus loses vitamin A and -carotene considerably after blanching, freezing, and deep freeze storage, and even after thawing at ambient temperature. Vitamin B-group losses rely mostly on the circumstances of the basic processing stages (washing, blanching). The remaining processes have no effect on B-vitamins. Vitamin C leaching by water or steam is harmful. Generally, preservation occurs during freezing and thawing. The preservation of vitamin C requires careful blanching and cold storage temperatures.

- Uncontrolled freezing can cause texture degradation, protein denaturation, and several other physical and chemical changes. There might be irreversible textural alterations indeep frozen veggies. Typical signs include softening, ductile stickiness, looseness, or flaccidity (a flabby softness, as in beans, cucumbers, and carrots); accumulation of a sticky, ductile, gum-like structure (asparagus) or a pasty, soggy structure (celery, kohlrabi); and hardening of the hull (peas).
- Producing pickled vegetables using spontaneous lactic acid fermentation. Fermentation enhances the product's digestibility and wholesomeness. The medium's acidic pH stabilizes vitamin C. Additionally, pickled veggies have a distinctive scent that is attractive.
- Canning, which requires heat sterilization, is one of the most essential methods for preserving vegetables. In comparison to other foods, vegetable sterilizing treatments are conducted at a greater temperature and for a shorter period of time (HTST sterilization). Thus, the products preserve a higher level of texture, fragrance, and color quality.

3.3.2 Nuts, oilseeds and spices.

Some oilseeds have gained enormous importance in the industrial production of edible oils on a big scale. You have already learned that the majority of fats and oils consist of triacylglycerols with varying fatty acid contents. The unsaponifiable fraction, which comprises less than 3 % of fats and oils, and a variety of acyl lipids, such as traces of free fatty acids, mono- and di-acylglycerols, are also present.

- Soybean and peanut (or groundnut) oils are extremely important to the economy. Low quantities of branched furan fatty acids in refined soybean oil are quickly oxidized upon exposure to light. This can lead to the creation of the intense fragrance component 3-methyl–2,4-nonandione, which, together with diacetyl, is implicated in the emergence of the olfactory defect known as reversion taste (bean-like, buttery, hay-like scent). Soybean oil is relatively stable in the full absence of light. By giving the oil a melting point between 22 and 28° or 36 and 43°, partial hydrogenation greatly extends its shelf life. These oils are used as raw ingredients for margarine and shortening production.

- The processing of fats and oils is essential for removing impurities contained in the raw material. To eliminate impurities, the refining procedure includes lecithin removal, degumming, free fatty acid removal, bleaching, and deodorization.
- Now, we will discuss spices. You are aware that dried or fresh plants with intense and distinctive flavors and fragrances are utilized as seasonings and spices. The scent components of the vast majority of spices exist as essential or volatile oils, which may be extracted using steam distillation. Mono- and sesquiterpenes or phenols and phenol ethers are the primary oil components. The most major pungent component of black pepper is piperine, which accounts for 3 to 8 % of the peppercorn's weight. Pepper is light-sensitive. During the processing and storage of ginger, gingerol readily dehydrates to shogaol, hence intensifying its pungent flavour.
- Spices are offered either whole or as coarse or fine powders. The flavor is enhanced by grinding the spices with a cryogenic mill. After grinding, spices have a short shelf life. Crushed spices quickly lose their scent and absorb other smells. Leaves and herb spices are dried prior to being pulverized. The loss of fragrance compounds is contingent upon the spice and drying conditions. Regarding scent preservation, freeze drying yields the greatest results when the water content is lowered to 16 %.

3.3.3 Cereal & cereal products, legumes

The grains may be kept without quality loss for two to three years if the kernel moisture content (which is 20 to 24 %) is lowered to at least 14 % after threshing. The kernel is composed of three components: the seed coat (bran), the endosperm, and the embryo or germ. Figure 2 illustrates these four elements.

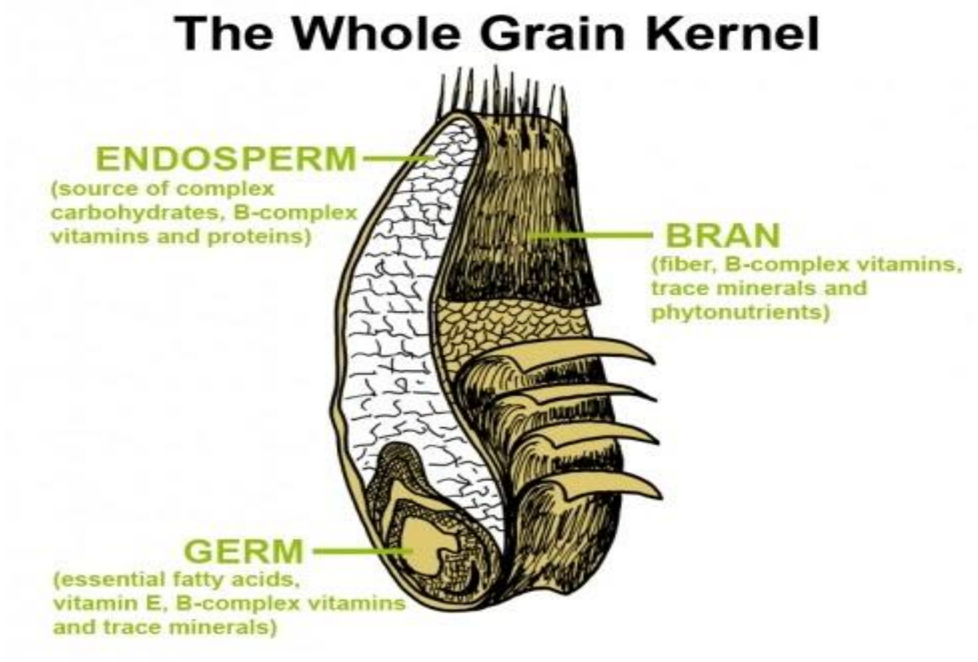


Figure 2: Cereal grain

- The purpose of milling (the process involving crushing and grinding) is to create flour in which the endosperm cell contents predominate. The exterior portion of the kernel is removed, including the germ and aleurone layer. 5 to 8 % of the wheat kernel's starch granules are mechanically destroyed during milling. The extent is contingent upon the type and intensity of milling as well as the hardness of the kernel, the tougher the structure, the greater the damage. Due to the fact that the rate of water absorption during dough preparation and the enzymatic destruction of starch rises with increasing damage, these factors are essential for the baking process and, to a certain degree, beneficial.
- The milling extraction rate affects the chemical makeup of

the flour. Increasing the rate of flour extraction reduces the quantity of starch while increasing the number of kernel-coating components such as minerals, vitamins, and crude fiber. Compared to wheat flour, rye flour has larger quantities of minerals and vitamins at the same extraction rate. In the case of some B-vitamins, including niacin, this disparity is well-balanced by the greater amounts of wheat kernels relative to rye kernels.

- Semolina is a commercial product manufactured from the endosperm cells of hard durum wheat. Semolina maintains its integrity throughout cooking and is mostly used to make pasta. As a milled flour with a poor extraction rate, semolina contains few minerals and vitamins.
- Vitamins of the B-group are lost to varying degrees during baking. White bread loses 20 to 50 % of its thiamine, 6 to 14 % of its riboflavin, and 0 to 15 % of its pyridoxine. By baking, the frothy texture of dough is transformed into the spongy texture of crumbs. At the comparatively high temperatures to which the dough's exterior is subjected, starch degrades into dextrin, mono- and disaccharides. Caramelization and non-enzymatic browning processes also occur, contributing to the crust's taste and color. The crust's thickness is determined by the temperature, baking time, and kind of baked goods.
- In the crust and crumb of white bread, aroma-rich substances play a significant role. Two heterocyclic

chemicals, furanol and 2- and 3- methyl butanol, are responsible for the roasty, malty, and caramel notes in the crust, while linoleic acid- methional and diacetyl contribute to the scent of the crumb. If the dough is fermented for a longer period of time, 3-methylbutanol and 2-phenylethanol, two byproducts of yeast, rapidly accumulate in the crumb and are responsible for the "yeasty" taste perception.

Baking's effect on dough:

- Active enzyme stage (from 30oC to 70oC).
- Phase of gelatinization of starch. (From 55 to 70 degrees)
- Phase of water vapor loss
- Phase of browning and aroma development.

- These modifications vary between the exterior of the dough and the interior of the crumb. Because heat transfer in dough is sluggish, there is a sharp temperature gradient inward from the dough's outside in the oven. The following are the sequences of changes that occur during the transformation of the frothy texture of dough into the spongy texture of bread and other products during baking at temperatures between 220oC and 250oC.

Chemical and physical modifications

- As heat permeates the dough when the dough is placed in the oven, the rate of fermentation initially rises. Up to 50oC, yeast produces increasing amounts of CO2 and ethanol. Simultaneously, the dough's viscosity decreases rapidly and reaches its lowest point at around 60°C. Simultaneously, the heat expansion of gas within each cell causes a fast increase in loaf volume, known as "oven spring."
- As the interior temperature of the dough rises over 37 °, the yeast's activity diminishes and becomes inactive around 54 °. In addition, the viscosity of dough rapidly increases over 60°C. This rise is generated by the expansion of starch, the release of amylose, and the denaturation of protein. As the crumb starch gelatinizes at 65 °, the existing - and -amylase will attack the starch. The amylolytic activity continues until the enzymes are inactivated at a temperature of around 74oC. Optimal amylolytic activity is required to restrict the breakdown of gelatinized starch in order to prevent bread from staleness. At around 74 °, denatured protein, swelled and partially gelatinized starch create a stable crumb network. This process continues until the interior temperature reaches 93 to 100 ° at the conclusion of baking. During this period, gluten loses its toughness and elasticity, becoming rigid and brittle.

- This stiffens the starch structure, resulting in the formation of a solid, elastic crumb. Nearly all of the starch granules on the surface of the crust gelatinize. This is especially true when the "oven humidity" is high; the resulting starch film creates a delicious glaze. This also delays the crust's drying and settling and allowing the dough to fully expand.
- This procedure results in a significant increase in the dough's tensile strength and the presence of air bubbles. Therefore, the membrane breaks down and becomes porous, enabling water, carbon dioxide, and ethanol to evaporate. This leads in weight reduction from baking. The inside temperature never exceeds 100°C, while the outside temperature approaches that of an oven (200°C). Thus, more water evaporates from the surface, and the crust forms. This results in weight losses of 8 to 14 % of the new dough during crust development.
- The high temperature to which the dough's outside is exposed. At 110°C to 140°C, starch degrades into dextrin, mono, and disaccharides. At 140-150°C, caramelization and non-enzymatic browning also occur, imparting flavor and color to the crust. The roasted flavors evolved between 150 and 200°C.
- In the crust, the heterocyclic chemicals pyrroline and pyridine, as well as furanone and 2- and 3-methyl butanal, which are responsible for the roasty, malty, and

caramel flavors of the goods, respectively, are created. Methional and diacetyl, two autoxidation derivatives of linoleic acid, also contribute to the scent of the crumb.

Changes during rice milling.

The milling of rice comprises the following steps:

- Paddy rice
- Dirt removal, we obtain brown rice.
- Rice polishing is the process of removing the bran coats (fruits and seeds) of the cuticle, the germ, and the aleurone layer to get white rice.

In contrast to brown rice, white rice has less vitamins and minerals, as seen in Table 6.

Table 6:Vitamin content of unprocessed, white, and cooked rice

B-Vitamins (mg/kg)			
	Thiamin	**Riboflavin**	**Niacin**
Raw Rice	3.4	0.55	54.1
White rice	0.5	0.19	16.4
Parboiled rice	2.5	0.38	32.2

A parboiling procedure, which was first devised to aid seed coat removal, can provide a nutritionally enhanced product. Approximately 25 % of the global rice harvest undergoes the following treatment:

- Raw rice
- steeping in hot water
- followed by drying and polishing following autoclaving.
- Parboiled rice

- This parboiling procedure results in the following changes: the starch gelatinizes, but then partially degrades after drying. The heat inhibits enzymes by inactivating them.
- during rice storage, the enzymatic breakdown of lipids. The oil droplets are shattered, and lipids travel partially from the endosperm to the rice kernels' outer layers. Rice that has been parboiled is more sensitive to lipid peroxidation due to the destruction of its antioxidants. In contrast, nutrients and vitamins seep from the outer layers into the inner endosperm, where they stay after the aleurone layer has separated. The cooking quality of parboiled rice is superior, and cooked parboiled rice lacks pastiness.
- Now, let's examine the processing-induced modifications that occur in legumes. Toxic compounds (e.g., cyanogenic glycosides and anti-nutritional factors, such as proteinase inhibitors, lectins, etc.) found in some legumes can be eliminated using processing techniques such as boiling.
- Individual cotyledonous cells disintegrate during the cooking process, resulting in the softening of beans. This is due to the conversion of protopectin to pectin, which depolymerizes rapidly upon heating. This process results in the disintegration of the central lamella of the cell wall, which is composed of pectin and supports the tissue.
- In contrast, the toughening of legumes after cooking is caused by the cross-linking of their cell walls. The following reactions which can commence even during storage at higher temperatures are under discussion as the source of cross linking. The current phytase hydrolyzes the calcium and magnesium phytates found in the middle lamella. In addition to meso-inositol and phosphoric acid, Ca^{2+} and Mg^{2+} ions are

also produced, which cross-link the pectic acids and fortify the middle lamella. Pectin esterase, enzymes that convert pectin to acid via demethylation, induce tissue calcification. In the case of legumes that are particularly abundant in phenolic compounds and polyphenol oxidases, the creation of complexes between proteins and polyphenols should contribute to the tissue's fortification.

- Sprouting legumes promotes a partial breakdown of carbohydrates and proteins, which adds to their enhanced digestibility. The unique flavor associated with sprouted legumes is a benefit. Sprouting has been demonstrated to trigger the hydrolysis of oligosaccharides, which are responsible for the flatulence of legumes.

3.4 Effect of cooking and processing on animal food

3.4.1 Dairy products and milk

In the dairy business, milk is frequently subjected to heat treatment for a number of reasons. Due to the production of insoluble complexes, protein denaturation, and interactions between milk components, this technique may produce many changes in the milk, including salt precipitation, depending on the heating temperature. A film or skin forms on the surface of milk when it is heated to approach the boiling point. This skin is mostly composed of calcium caseinate;however, it also contains the other milk components.

- Have you ever observed what happens to milk when it is heated over its boiling point? When milk is autoclaved at an approximate temperature of 121 °C, it becomes brown. The brown color is caused by a reaction between the casein (or amino acids) and the sugar, which is triggered by the heat. Changes in milk's physical and chemical characteristics are also influenced by the method used to heat the substance. The effects of indirect heating (steam injection) on the physical and chemical characteristics of ultra-heated milk (95°C to 145°C) were much greater than those of direct heating (steam injection), according to research. In milk that was ultra heated, browning intensified and whey protein denaturation increased.

- Depending on the temperature and length of heating, milk additionally undergoes taste variations in addition to the aforementioned modifications. A cooked flavor develops when milk is heated to high temperatures. In the holding technique of pasteurization (62°C for 30 minutes) or the high-temperature short-time (HTST) method (71°C for 15 minutes), very little cooked taste is detected. However, at higher temperatures or longer heating times, cooked flavor becomes more pronounced. Upon temporary heating to 70°C, the taste emerges. This cooked flavor is attributed to the formation of sulfhydryl (compounds with a -SH group, present in many plant and animal enzymes) at high temperatures. Sulfhydryl compounds are quickly oxidized and retard the oxidation of milk or cream fat at elevated temperatures. Until the sulfhydryl are oxidized and the cooked flavor has vanished, oxidizedflavors in milk often do not manifest.
- Milk's composition and characteristics are also significantly altered by freezing. As milk freezes, the composition of the frozen and other solids becomes extremely inhomogeneous, while the liquid component becomes highly concentrated with milk solids, to the point that milk never completely freezes solid. Milk's physical state is irreversibly changed by freezing. It causes the fat globules to lose their whole emulsion structure, cluster together, and become deformed and uneven in shape and size. Freezing has an effect on casein as well. It is precipitated as flakes as calcium caseinate is partially separated from its presence in milk. This state, together with the presence of certain free fat particles, imparts an odd look to the thawed milk. Affected as well is the flavor, which is fairly watery.
- Freezing has the potential to disrupt the heat-stable caseinate micelles of milk. When milk is frozen, the caseinate's stability degrades with time and may result in total coagulation.
- Casein is a notable example of a protein that can be cooked without

much alteration in stability. Milk may be boiled, sterilized, and concentrated without coagulation due to the extraordinary stability of casein.

- Now, we'll examine the variables that impact viscosity. Low temperatures and ageing enhance the viscosity of milk by causing the fat globules to clump together. Mechanical agitation lowers the viscosity of whole milk because the fat globule clumps are partially broken up, however in the case of skim milk, mechanical agitation has no impact due to the absence of lipids.
- As the fat globules in homogenized milk have already been broken down, the milk will not be harmed. The viscosity of whole milk is increased by homogenization, whereas that of skim milk is somewhat decreased. This procedure reduces the size of the fat globule, hence increasing its surface area. A protein film is adsorbed on the surface of the globules, and because this surface is considerably bigger than in non-homogenized milk, a significantly greater adsorption occurs, resulting in a greater viscosity. Some of the protein particles in skim milk may be disrupted, resulting in a decrease in viscosity.
- Pasteurization temperatures somewhat reduce viscosity by dispersing fat globule clusters, but high temperatures or pressure increase viscosity by denaturing proteins.

3.4.2 Meat and poultry

- Meat, as you probably well know, is protein-rich and includes the majority of important amino acids. In addition, it is rich in minerals such as copper and iron, as well as vitamins A, B1, B2, and B3. Depending on the kind, breed, diet, and age of the animal, its fat content ranges from 5 to 40%. Meats are abundant in saturated fatty acids (SFA). A brief description of the impact of thermal processing on meat products might be provided. It is becoming increasingly apparent that the kind and amount of the alterations that occur within the muscle as it transforms into meat may significantly influence its behavior.

- It is vital to note that too successful cooling of heated carcasses might lead to hardness. If the temperature of the meat (muscles) may be lowered to -10 to -15°C while they are still in the early pre-rigor state (pH between 6.0 and 6.4), there is a propensity for shortening and, consequently, harshness during later cooking. The term for this phenomenon is "cold shortening." When the temperature reached by the pre-rigor muscle is closer to the freezing point, the propensity of cold shortening increases.
- Researchers have paid close attention to the impact of irradiation on the nutritional content of meats and poultry since it has been cited as a justification against the process's approval and commercial implementation. The most unreasonable aspect of this controversy is the consistent emphasis on the negative effects of irradiation on food nutrients, including those in meat and poultry, which has been largely reported by extrapolating data from studies in which isolated, selected nutrients were irradiated in model systems.
- In terms of amino acid composition, strong radiation doses such as those required for sterilizing (e.g., 25-27Kgy) had little effect on the level of cystine, methionine, and tryptophan in beef, despite the fact that these amino acids are extremely sensitive to destruction by other mechanisms.
- Numerous studies demonstrate the impact of processing on vitamins, particularly thiamine. In research comparing the effects of ionizing radiation and normal thermal processing on the thiamine content of enzyme-inactivated ground pork, it was determined that conventional thermal processing led to a decrease in thiamine content.
- thiamine losses in pork were equivalent to or larger than those produced by radiation sterilization.
- Another research investigated the influence of irradiation, storage, and cooking on the thiamine level of ground pork. The pork was irradiated at 1Kgy while wrapped in polyethylene bags at room temperature, then stored at 0°C for 8 months with or without heating for 10 minutes at

100°C or 30 minutes at 200°C prior to irradiation. The results obtained are as follows. Losses of thiamine in unheated pork samples immediately following irradiation were 5%, but losses during refrigerated storage at 0°C were identical to those in non-irradiated samples. Heating pork at 100°C for 10 minutes before to irradiation had no influence on the thiamine loss observed in unheated, irradiated samples.

3.4.3 Fish

Fish skeletal muscle has small fibers placed between sheets of connective tissue. Fish muscle contains less connective tissue than mammalian muscle, and its fibers are shorter than those of mammalian muscle. Fish has a more delicate feel than beef due to the distinct physical qualities of its tissues. The myofibrils of fish muscles resemble those of mammalian muscles in that they are striated and contain the same four key proteins, myosin, actin, actomyosin, and tropomyosin.

- During processing and storage, actomyosin from fish is shown to be very unstable and susceptible to alteration. During freezing, actomyosin becomes gradually less soluble and the flesh gets progressively harder. Proteins derived from fish are more prone to instability during freezing and storage. The fish may become brittle and lose moisture after being frozen.
- The nutritional value of protein does not appear to be considerably changed by exposure to time/temperature procedures during canning, according to studies on the effects of heat processing on fish. Salmon and sardine bones, for example, are softened to the point that they may be consumed. Protein denaturation by heat results in water losses ranging from 9 to 28%, depending on the intensity of the process/pre-process, the species, the pH, and other physiological parameters.
- Changes in texture caused by heat processing are also unavoidable and might be helpful to a limited degree. Excessive protein denaturation and the resulting loss in the water-holding capacity of the structural

components result in a product with a dry and chewy texture. However, oily-flesh fish display fewer of these effects due to the restricting effects of lipids on water migration. In this regard, the choice of raw material is crucial, since less fresh fish loses more water and, thus, exhibits higher textural degradation following processing.

- In the section on fruits and vegetables, we have previously examined browning. Are you able to recollect which components caused the reaction? Sugars and amino acids, indeed. Similarly, the number of sugars and amino acids in fish may be responsible for Maillard-type reactions that occur during heat processing.
- Proline is a common amino acid in fish and may add to sweetness. The sugars ribose, glucose, and glucose-6-phosphate contribute to flavor, as does 5-inosinic acid, which imparts a meaty taste. Volatile Sulphur molecules add to fish flavor; hydrogen sulphide, methyl mercaptan, and dimethyl sulfide may contribute to fish fragrance.
- Usually, ribose is responsible for the browning of canned fish. During canning, undesirable color changes in shellfish frequently result from the presence of metal ions; for instance, the blue discoloration of crab flesh is due to the presence of iron, whereas the black discoloration of prawns is due to the presence of copper. Due to the high iron concentration of the raw material, the processing of eels, abalone, and albacore tuna results in discoloration. Due to the accumulation of free Sulphur in the tissue, the discoloration of this sort of material is exacerbated by freezing storage prior to canning. Iron and free Sulphur react during heat processing, precipitating black iron sulphone on the edges of the container, in the fish itself, and most notably in any free liquid.
- Comparing fresh and canned fish has indicated slight losses of B-group vitamins, thiamine, riboflavin, nicotinic acid, folic acid, and cyanocobalamin.
- Do you know what causes fish flesh to go rancid? Fish rotting is caused by a number of variables, including differences in the composition of

tissues between species, environment, procurement, and storage procedures.

- Fish flesh that has been subjected to significant autolysins during spoilage may result in a heat-processed product with a pitted or honeycombed texture, whereas a limited amount of proteolysis before to processing may result in a desired softening of the texture of the final product.

3.4.4 Egg

The pace and circumstances of handling, uncoated shells, storage durations and temperatures have a higher and more immediate negative impact on the quality, flavor, composition, and functional qualities of eggs.

- Eggs that have been frozen or dehydrated are nutritionally equivalent to fresh eggs. There is no considerable loss of nutrients throughout the drying or freezing operations. Properly
- Eggs that have been dried and frozen exhibit no nutritional loss over time. The following facts provide support for this assertion.
- A study of the thiamine content of hard-cooked eggs versus scrambled eggs revealed that neither preparation method was superior. However, scrambled eggs had 20% less riboflavin than hard-cooked eggs. Both cooking procedures resulted in the same loss of threonine (an amino acid), 0.22 %.
- Under typical conditions, the drying of eggs results in minimal loss of nutritional value. It has been discovered that the levels of vitamin A, vitamin B, thiamine, riboflavin, pantothenic acid, and nicotinic acid in dried whole egg are comparable to those in fresh egg product. The protein content of dried eggs has not changed significantly. Unfavorable drying conditions or poor storage conditions may compromise nutritional qualities. Nevertheless, any egg product that lacks an off flavor will likely retain all of its nutritious qualities.
- In general, egg products retain their heat-coagulating capabilities during the drying process. If drying conditions are excessively harsh or storage

circumstances are unfavorable, whole egg and yolk products can lose their solubility, which is accompanied by a loss of heat-coagulating capabilities. Increased viscosity upon reconstitution is one symptom of high heat during the drying of plain whole egg and plain yolk. The viscosity of dried plain yolk changes substantially more than that of dried plain egg whites or entire eggs. During storage, it is possible to see a rise in the viscosity of whole egg and yolk products. At temperatures exceeding 100° F, the viscosity of reconstituted liquids increases relatively fast.

- Dehydration has no bearing on the density of egg products. When a dried egg product is reconstituted to its original solids, it has about the same density as the liquid from which it was extracted. Depending on the techniques and conditions of drying, the bulk density of dried egg products might vary substantially. Egg products that are pan-dried have a significantly greater bulk density than their spray-dried equivalents. The lowest bulk density is found in freeze-dried egg products.
- Changes in the chemical characteristics of the egg's numerous constituents are responsible for the modifications in functional qualities. Proteins comprise most of the egg white, as you know. Consequently, any changes that occur in egg white after drying appear to be a result of alterations in these proteins. Denaturation and coagulation of proteins are considered chemical alterations because they entail the unfolding of proteins, which exposes specific chemical groups, such as the sulfhydryl group, thereby modifying the proteins' chemical reactivity. Since water is an essential component of the protein molecule, removing it from egg white may alter its characteristics.
- The presence of glucose in eggs can cause chemical alterations during drying and storage. The process in egg white includes the reducing or aldehyde groups of glucose and the amino groups of proteins (Maillard reaction). This reaction leads to the formation of a brown hue and a decrease in solubility. Drying to a low moisture content and lowering the

pH reduces the reaction. Since glucose comprises around 4% of the solids in egg white, the glucose has been eliminated from all dried egg white.

- The transformations that occur in egg-yolk and yolk-containing egg products are significantly more complicated than those in egg white. The interaction with glucose might also result in modifications to the egg yolk and egg product. In this instance, glucose might react with the amino groups in both protein and cephalin. During storage, off-flavors and odors are produced due to the interaction with cephalin. The process may be stopped by removing glucose and is also hindered by adding carbs such as sucrose.
- As noted earlier, the differences in viscosity of plain egg yolk and entire egg are attributable to the changes in lipoproteins. The lipids account for roughly 45 % of the solids in a whole egg and 60 % of the solids in the yolk, and hence play a predominate role in the changes that occur after drying. 62 % of egg yolk lipids are glycerides, 33 % are phospholipids, and 5 % are cholesterol. Lecithin accounts for 73% of phospholipids, while cephalin accounts for 15%. This oxidization
- Approximately 100 times faster than lecithin, the rate of cephalin synthesis is incredibly quick. This connection between these phospholipids and protein requires the presence of water. The equilibrium changes when water is removed. In general, removing water from lipoproteins without altering their characteristics is challenging.
- Gelation, which happens when yolk is frozen and thawed, appears to be caused by the aggregation of yolk lipoproteins due to the water imbalance and shift. Carbohydrates inhibit a rise in the viscosity of egg yolk during drying and storage.

Summary

In this unit, we studied about chemical, physical and nutritional changes that occur in foods during processing and storage. These alterations were already among a variety of food groups such as fruits and vegetables, milk and milk products, meat and poultry, fish, egg, cereal, cereal products and legumes, and nuts and oilseeds. A number of processes that occur because of such alterations were also dealt with, such as browning, caramelization, gelation etc.You have also learnt about the perspective of food processing in the current scenario, that is, you came to know of the various desirable and undesirable changes that occur during processing of foods.

Progress Exercise

1. The source of carbohydrates in fresh fruits is available in which form?
2. Give the name of a component that is common to both fruits and vegetables and undergoes a reduction in quantity during the process of ripening is?
3. The predominant pigments found in fruits and vegetables are?
4. The process of cooking fruits and vegetables leads to alterations in the composition of cellulose are?
5. The enzyme that becomes activated during the initial month of storage of musk melon is?
6. The primary constituent of the film that is produced on milk when it is heated is?
7. Delaying the oxidation of fat in milk or cream that has been subjected to high temperatures is by
8. The viscosity of milk is significantly impacted by mechanical agitation, while it does not have any discernible effect on the viscosity of which milk specify the name.
9. Browning was induced in heated milk explain with reason.
10. The presence of a cooked flavor in milk is due to the?
11. What is cold shortening?

12. What are the differences in the occurrence of the Maillard reaction between egg whites and egg yolks?
13. Explain the term 'Gelation'.
14. Explain the Maillard reaction leading to the browning phenomenon.
15. How cereals can maintain their quality during storage?
16. What are the changes that occur during a particular process or event:

a) The process of baking cereal grains.

b) The storage of bread.

17. What are the factors that contribute to the softening and hardening of legumes during the cooking process?

UNIT 4: PROCESSING OF FRUITS AND VEGETABLES

STRUCTURE

1.1 Introduction

  1.1.1. Processing system

1.2 Classification of fruits and vegetables

  1.2.1. Classification of vegetables

  1.2.3. Classification of fruits

1.3 Importance of fruits and vegetables

1.4 Composition of fruits and vegetables

1.5 Effect of cooking and other processing method on the nutritive values

1.6 Food pigments

1.7 Browning reaction in fruits and vegetables

  1.7.1 Method for controlling enzymatic browning

1.8 Classification and importance of beverages

  1.8.1 Non-alcoholic beverages

  1.8.2 Alcoholic beverages

  1.8.3 Importance of beverages

1.9 Food additives

  1.9.1 Types of food additives

  1.9.2 Uses of food additives

  1.9.3 Legal aspects of food additive

1.10 Leavening agents

  1.10.1 Function of leavening agent

  1.10.2 Type of leavening agent

1.11 Let us sum up

1.12 Answer to check your progress

1.1. INTRODUCTION

In developing country like India agriculture is the main source of economy. Also the agricultural industries are related to activities consider for the output. Out of various types of activities include in agriculture the fruits and vegetable processing is the most important processing.

In human dietaries the fruits and vegetable are the most demanded and important ingredient. Fruits and vegetable sometimes become uneconomical due to their nature of being seasonal and the price varies according to season and glut period. Thus to increase the value of the production of fruits and vegetables the product should be handled, utilized or processed properly. The processing has more attention in the recent years because the cost that is involved in preventing the losses is always cheaper than production cost.

The Indian industries of fruits and vegetable processing are highly unorganized. The prominent proceeds items include canned fruits and vegetables, fruit juice, fruit pulp, Ready to serve beverages of fruits, squashes, jams, pickles, dehydrated vegetables and chutneys, etc.

The main objective for the processing of fruit and vegetable is to supply wholesome, nutritious, safe and acceptable food to the consumers for the whole year.

In developing countries the processing of fruits and vegetables has been developed for one of the following reasons:

- To reduce the dependency on export.
- Due to government policy of industrialization.
- To reduce the demands of export and imports.
- To stimulate the production of agriculture by obtaining the marketable products.
- To generate employment in rural and urban.
- To reduce the loss of vegetables and fruits.
- To develop new product.

1.1.1. Processing systems

a. **Small-Scale Processing**.

The small scale processing includes small scale farmers for sale in markets of for personal subsistence. This system requires little investment but it is time consuming and tedious. The small scale processing satisfied the needs of urban and rural population. However, the rising rate of growth of population and urbanization there is more diversity in food demand, so there is need for more diverse and processed food.

b. Intermediate-Scale Processing.

In intermediate –scale processing, group or individual of small-scale pool their resources. The small-scale processor use different type of technology and capacity to use the instrument. The raw material are usually grown by the processor themselves or purchased from farmers on contract. This processing is usually carried out in the site of production so that the raw material is available and the transport cost is reduced.

c. Large-Scale Processing.

Large scale processing requires a supply of raw material and is highly mechanized. A large capital investment is required in this system also high technical and skill to manage. Many large scales of factories have been established recently due to high demand of food in developing countries. Some of these industries succeeded but majority of them failed. These failures were due to relatively high cost and lack of skills to manage. The main reason of the failure was lack of quantity and regularity of supply of raw material to factories.

1.2. CLASSIFICATION AND IMPORTANCE OF FRUITS AND VEGETABLES

1.2.1. Classification of vegetables

Classifications of vegetables are according to the part of the plant that is eaten. Some of the vegetables can fit in more than one category i.e. more than one part of the plant is eaten. Example: The root as well as the leaves of the beetroot can be eaten.

Table: Classification of table

Part of the plant	**Description**	**Examples**
Bulbs	The part of the plant that grows just below the ground surface and produce shoot above the ground which is fleshy and leafy. The bulbs consist of layers or clustered segments.	Fennel, leek, garlic, shallot, onion, spring onion.
Flowers	Certain vegetables have flowers that can be eaten.	Artichoke (globe), cauliflower, broccoli, squash flower, choi sum, gai lan

CLASSIFICATION AND IMPORTANCE OF FRUITS AND VEGETABLES

Fruits	The fruits and vegetable are fleshy and it contain seeds.	Capsicum, bitter melon, choke, chilli, cucumber, courgette, fuzzy melon, eggplant, Indian marrow, plantain, marrow, squash etc.
Fungi	A commonly know fungi is known as mushroom when referring to vegetables.	Swiss brown, button, enoli, portbello and oyster etc
Leaves	The leaves of the plants that is edible.	Brussels sprouts , bok choy, cabbage ong, lettuce , radicchio, spinach etc
Root	Taproot those are usually long or round.	Carrot, beetroot, celeric, parsnip, daikon, radish, turnip, swede.
Seeds	Some seed can be eaten which grows in a pod.	Sweet coarn pea, snow pea, bean, broad pea.
Stems	When the stalk is the main part of plant they are edible stalks.	Kohlrabi, asparagus, celery
Tubers	Underground root of the plant grow vegetables.	Jerusalem, earth gem,

Table: classification of fruits.

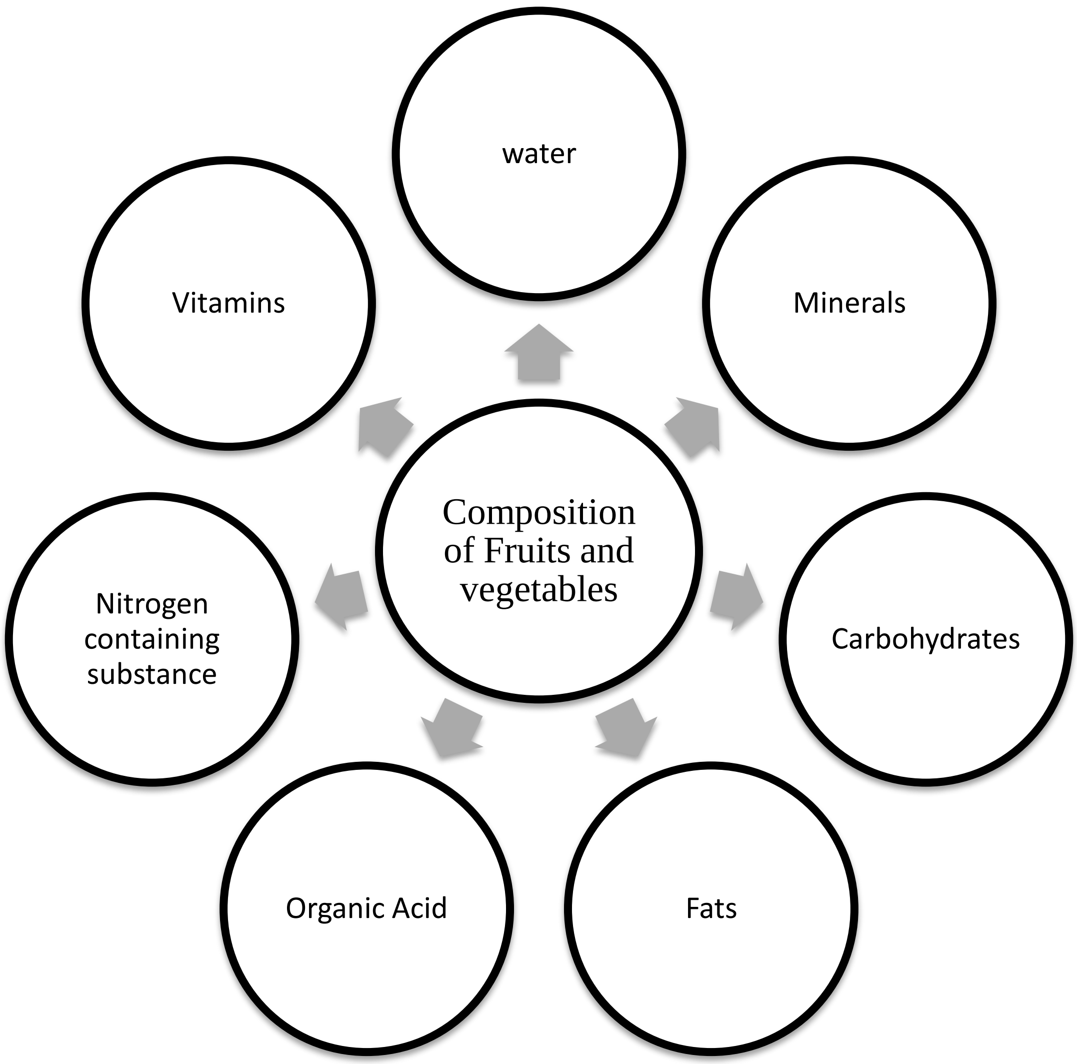
Type of fruits	Examples
Pomme	Apple, pear Nashi
Citrus	Orange, Lemon, mandarin
Berry	Strawberry, Raspberry, Blueberry
Stones	Apricot, plum, peach
Vine	Grapes, kiwi, passion fruit
Tropical	Banana , mango, pineapple
Melons	Watermellon, rockmellon

1.3. IMPORTANCE OF FRUITS AND VEGETABLES.

1. **Fruits and vegetables are excellent source of vitamins and minerals. Fruits and vegetables are packed with various vitamins such as vitamin A, C and E and also with minerals like magnesium, phosphorous, zinc and folic acid.** Potassium is one of the most important minerals required for a good health, it can be fulfilled by consuming avocados, bananas, sweet potatoes, prunes and tomato.
2. **It has a variety of flavors and textures.** Fruits and vegetables have unique and interesting flavors, which makes you creative in the kitchen. They have strong flavors like onions, peppers and olives or milder flavors like corn and mushrooms. Fruits like grapes, pineapple and plums are sweet in nature where as grapefruit and lemon is sour.
3. **Rich in fiber. Majority of** fruits and vegetables are rich in fiber and important for gut health. Fiber-rich vegetables are green peas, artichokes, broccoli and cauliflower. Raspberries, apple, pumpkin and pears are high fiber fruits.

4. **Fruits and vegetables are in low fats and calories. Fruits and vegetables are low in calories so you can eat as much as you want and still not worry about your weight.**
5. **Protect against diseases.** Fruits and vegetables contain phytochemicals, a biologically active substances which helps to protect against some diseases such as lower the risk of type 2 diabetes, cancer, stroke, heart disease, and high blood pressure by including them into your diet. The cruciferous veggies, such as
6. broccoli, collards, cabbage, collards and watercress, have ability to reduce cancer risks.
7. **Fruits and vegetables keep a check on your good health.** Fruits and vegetables are low in saturated fat, sugar and salt, so are part of a well-balanced diet. They facilitate in weight loss and prevent weight gain. They can also help to decrease inflammation and lower blood pressure and cholesterol levels.
8. **Low in cholesterol and sodium.** Fresh veggies and fruits have only trace amounts of sodium. And no Cholesterol is present in fruits and veggies at all.

1.4. COMPOSITION OF FRUITS AND VEGETABLES



1. **Water**

The Vegetal cells have good quantities of water. Water is important for reproduction cycle and evolution and in physiological processes. The vegetal cell varies water in various forms such as true solution with mineral and/or organic substance. Vegetables contain generally about 90-96% water where as in fruit the normal water content is between 80 and 90%.

2. **Mineral substances**

Mineral substances that are present in fruits and vegetables are in the form of salts of organic and inorganic acids or as combination of complex organic compound (chlorophyll, lecithin, etc.). Vegetables contain more mineral substances in compared to fruits. The mineral substance present is between 0.60 and 1.80% and there are more than 60 elements present. Major of the elements include K, Ca, Na, Mg, Mn, Fe, Al, S. Cl, P. The vegetables which are rich in mineral substances are: spinach, cabbage, tomatoes and carrots

3. **Carbohydrates**

For about 90% of the dry matter is composed of carbohydrates in fruit and vegetables. An adult should consume about 500 g of carbohydrate daily. Carbohydrates play a important role in biological systems and in foods. Photosynthesis in plants helps them to produce carbohydrate. They serve as structural components in case of cellulose and are stored as energy reserves in case of starch in plants. They function as essential components of nucleic acids in case of ribose and as components of vitamins such as ribose and riboflavin.

4. **Fats**

Generally fruit and vegetables are low in fats i.e., below 0.5%. However, in nuts (55%) significant quantities can be found , apricot kernel (40%), grapes seeds (20%), apple seeds (16%) and tomato seeds (18%).

5. **Organic acids**

Fruit contains various natural acids, such as citric acid in lemons and orange, tartaric acid of grapes and malic acid of apples. The acids enhance fruits tartness and slow down the bacterial spoilage. Food is fermented with desirable bacteria so that it produces acids and gives the food a flavour and maintains the quality. Examples: cabbage fermentation produce lactic acid and fermentation of apple juice produce first alcohol and then convert to acetic acid to obtain vinegar.Organic acids also influence the colour of foods , hence, plant pigments are natural pH indicators.

6. Nitrogen-containing substances

Nitrogen is founend in combonation frm such as amino acids, proteins, amides, amines, nitrates, etc. Nitrogen containing substance in vegetables are between 1.0 and 5.5 % while in fruit this substances are less than 1% in most cases.

7. Vitamins

Vitamins are organic materials which must be supplied in human body in small amounts. Vitamins function as enzyme systems that facilitate the metabolism of carbohydrates, proteins and fats.

The vitamins are divided into two major groups, fat-soluble vitamins and water-soluble vitamins. Fat-soluble vitamins include A, D, E and K.

Water-soluble vitamins are vitamin C and the members of the vitamin B complex.

8. Enzymes

In fruit and vegetables the enzymes control the reactions which are associated with ripening. After harvesting fruits and vegetables, unless the enzyme is destroyed by heat, chemicals or some other means, they continue the ripening process, in may lead to the point of spoilage - such as soft melons or overripe bananas. The enzyme goes through a vast number of biochemical reactions in fruits and vegetable, which may be responsible for changes in colour, flavour, texture and nutritional properties. The heating of fruit and vegetables in manufacturing/processing are designed to destroy micro-organisms as well as to deactivate enzymes which is important to improve the storage stability of fruit and vegetables. The optimal temperature of enzymes is around +50°C where their activity is at maximum. Heating of enzyme beyond this optimal temperature will deactivates the enzyme.

1.5. EFFECT OF COOKING AND OTHER PROCE THE NUTRITIVE VALUE OF FRUITS AND VEG

EFFECT OF COOKING AND OTHER PROCESSING METHOD ON THE NUTRITIVE VALUE OF FRUITS AND VEGETABLES

The foods that we consumed required some form of making it fit for consumption. The nutrients that we depend on the extent of cooking practices used. While lost but cooking also have its benefits like:

- Cooking increases food palatability
- It makes the digestion of food easily
- Cooking destroys the Pathogenic micro-organisms
- It improves the appearance of food.

When the food is prepared in large quantities in institutional kitchens or food processing plants it becomes is more prone to the loss of nutrients if proper care is not adopted to preserve its nutrients.

In the initial stages of cooking when the food is soaked in water it leads to leaching of some vitamins and minerals. We can minimize the loss by washing the fruits and vegetables before cutting it and by not soaking them in water.

The effects on the nutrients maybe due to heat, alkali, and

EFFECT OF COOKING AND OTHER PROCESSING METHOD ON THE NUTRITIVE VALUE OF FRUITS AND VEGETABLES

Effect of Heat on the Nutrients

- While cooking carbohydrates, it has a beneficial ef carbohydrate leads to gelatinization of starch and caramelization of sugar that is responsible to give color and flavor to food.

- Cooking denature the proteins and access to enzymes and increases digestibility.
- When the pulses is moist heated it improves the quality of protein.
- When oil is continuously heated some chemical reactions take place which include the reactions like hydrolysis, polymerization and oxidation of the oil. When the oil becomes dark and foamy it should not be used for consumption
- Certain enzymes are inactivated while blanching that lead to undesirable browning.
- Cooking cause loss of heat labile vitamins.
- If the product is not coated properly while frying the fat-soluble vitamins are lost.

Effect of Alkali on Nutrients

- To soften the vegetables alkali are used while co bicarbonate can add to the brightening of green vegetabl
- Alkaline medium destroys the B complex vitamins and V
- If the food is cooked excessively in the alkaline medium it destroys vitamins and makes the texture of the food mushy while giving a soapy taste to the product.

Effect Of Acid On Nutrients

- Cooking in an acidic medium helps in preservation of water-soluble vitamins and reduces enzymatic browning of fruits and vegetables.

- The time taken to cook vegetables and pulses in an acidic medium take a longer time as the acids precipitate the pectin and harden the vegetables.
- The volatile acids should be allowed to escape first as the vegetables can lose their color, hence the led should be open while cooking greens for the first few minutes.

Guidelines for Preserving Nutrients

EFFECT OF COOKING AND OTHER PROCESSING METHOD ON THE NUTRITIVE VALUE OF FRUITS AND VEGETABLES

- Sufficient amount of water should be used to wash veget
- Cooking should be in a minimum amount of water or th used in soups and gravies.
- Cutting vegetables in large pieces and for a shorter time to prevent the loss of vitamin C.

There are 3 R's of cooking so that the nutrients are conserve :

1. Reduce the water amount.
2. Reduce the time of cooking period
3. Reduce the amount of surface area that is exposed

1.6. FOOD PIGMENTS

FOOD PIGMENTS

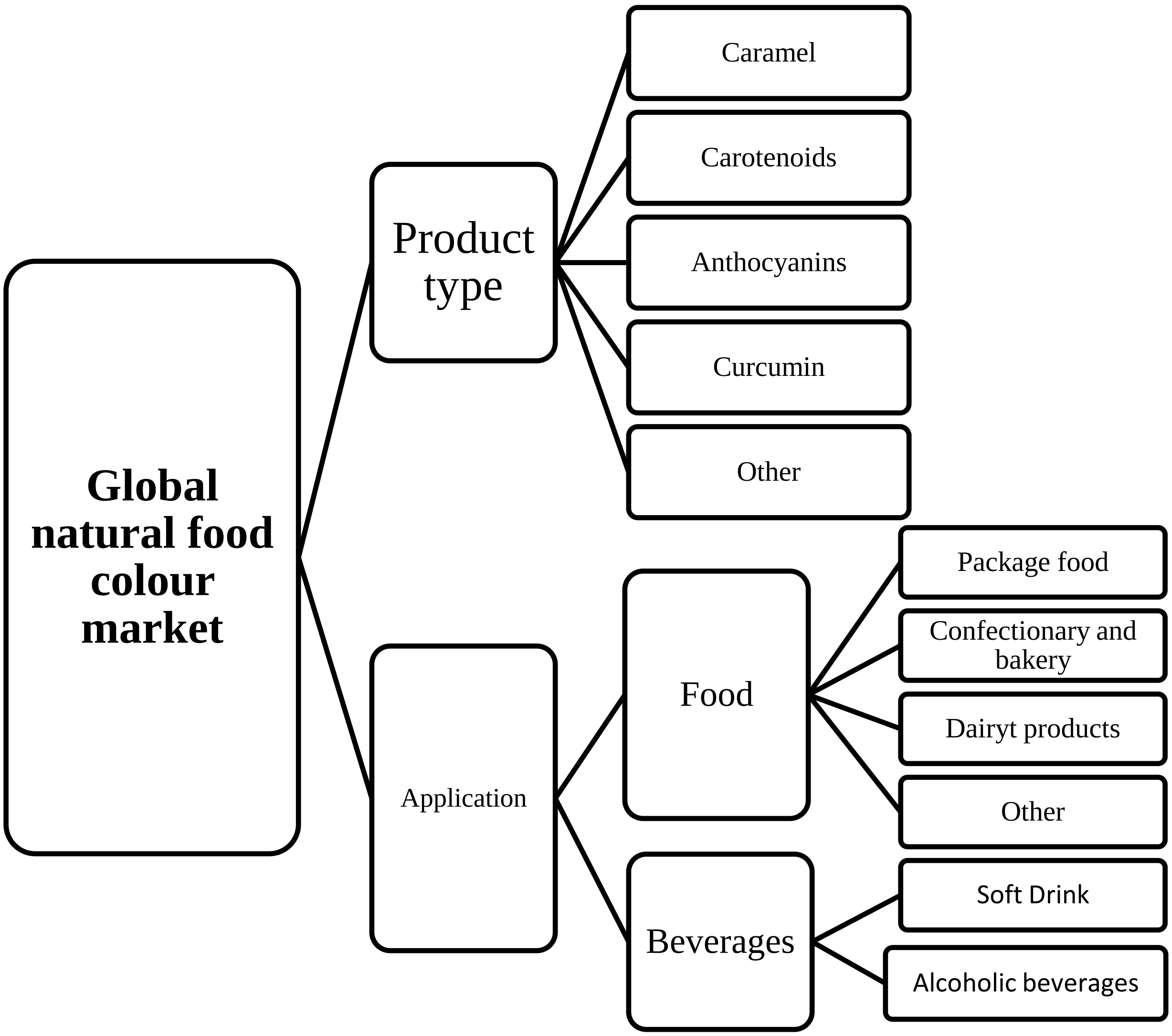
Food Pigments are compounds that can absorb light i

is of visible region. This absorption occurs due

structure (chromophore) that can capture the energy from a radiant source. Some energy cannot be absorbed so it is reflected and/or refracted. The reflected energy is captured by the eye and then generates neural impulses, which are further transmitted to the brain, where they interpret as a color.

In living organism the pigments are widely distributed, and numerous number of structures can be seen. Some of these pigments of food are described below:

Fig: Food pigments



Chlorophyll :

The green pigment of leafy vegetables and other gr
known as Chlorophyll.

Carotenoids:

The yellow, red, orange, fat soluble pigments that are distributed in nature is called carotenoids. They are mainly divided into three groups i.e., the carotenes present ingreen leafy vegetables, carrot and other fruits, lycopenes which is present in tomatoes and xanthophylls that are present in yellow fruits.

Pigments containing phenolic group include, anthoxanthin, anthocyanin leucoanthoxanthin, quinines catechin, and betalins. The first four groups can collectively called as 'Flavanoids'

Anthocyanin :

They are a group of water-soluble pigments which is reddish in color and occur in many fruits and vegetables. The color of Cherries, pomegranates and red apples is due to anthocyanins.

Anthoxanthins :

Anthoxanthin are colourless white to yellow pigments
colour of cauliflower, spinach, onions, or other leafy vege

Leucoanthoxanthins :

They are colourless and are responsible for puckeriness or astringency of some foods, such as olives and apple. They also important for the enzymatic browning of fruits.

Catechins :

Catechins are pigments that are responsible for enzymatic browning.

Betalins :

The red water soluble pigments found in beetroot and berries are called Betalins

Quinone :

The yellow pigment in walnut is Quinone.

Mangiferin :

This is the yellow pigment is found in mango, they belong to the xanthone group.

Tannins :

BROWNING REACTION IN FRUITS AND VEGETABLES

A complex mixture of polymeric polyphenols is tannins range from colourless to yellow or brown. Ta astringency of foods and also for the enzymatic browning.

1.7. BROWNING REACTION IN FRUITS AND VEGETABLES.

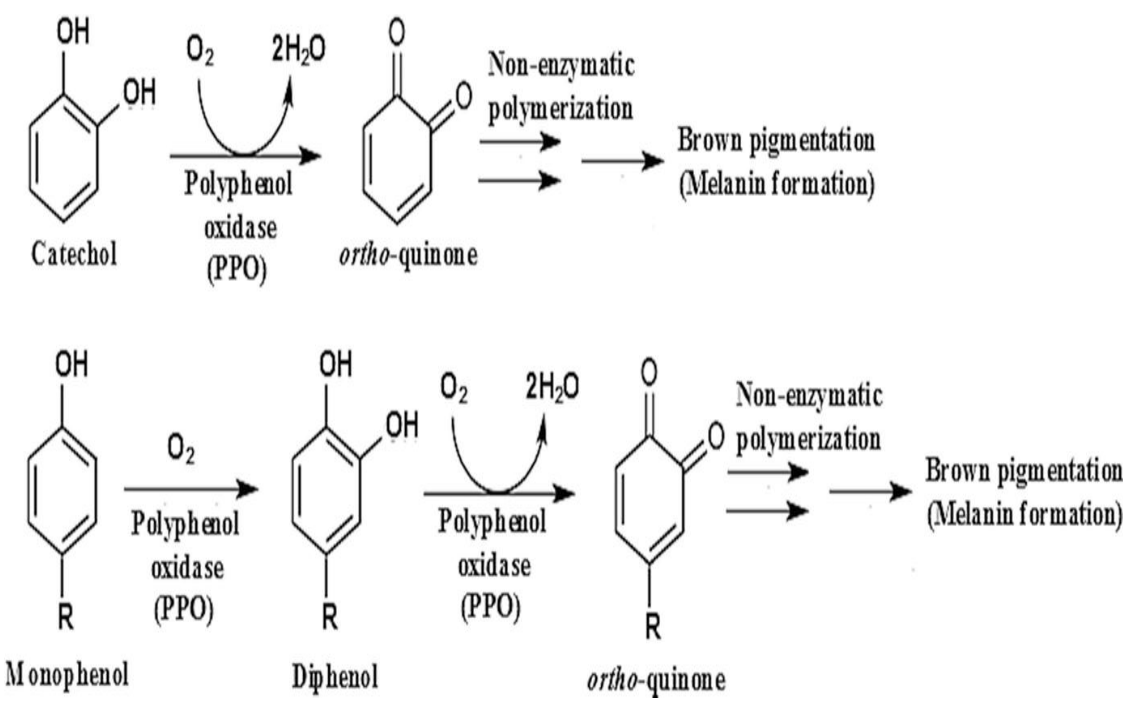
We all have seen the browning in apple or in potato when they are cut into pieces and kept for some time in the open air. This is due to the enzymatic browning in fruits and vegetables. Phenolase browning are commonly called enzymic browning it has great commercial significance, particularly in fruits and vegetables the phenolase enzymes are common.

In intact tissue, the phenolic substrates separate from phenolase and there is no browning. Enzymic browning is visible on the surfaces of light-colored fruits and vegetables, such as banana, apple, and potatoes.

BROWNING REACTION IN FRUITS AND VEGETABLES

There are various enzymes that can catalyze oxidatio commonly known as phenolases this include poly catecholases or tyrosinases.

If tyrosine is in the substrate, the phenolase catalyzes its hydroxylation to DOPA, and then catalyzes oxidation of DOPA to DOPA quinone. The remaining reaction sequence involve non-enzymic oxidations and an ultimate polymerization of indole 5, 6-quinone to brown melanin pigments.Finally, the melanins interact with proteins and forms complexes.



1.7.1. Method for controlling enzymatic browning

1. **pH control**

Phenolase are active between pH 5 and 7 and they
optimum. When the pH is low up to 3, the enzyme is irreversibly inactivate

2. **Exclusion of oxygen**

It is the most commonly used method for controlling enzymic browning. Example: dipping the slice of potato in water before frying which helps to avoid enzymic browning of potato.

3. Use of sulphur dioxide or sulphite

In this method the product that can undergo textural or flavour changes upon heating is used. It is the powerful inhibitors of polyphenol oxidase.

4. **Application of heat**

Application of high temperature of heat used for the food processing at an adequate length of time can inactivates phenolase and all other enzymes present.

5. Exclusion of oxygen

It is the simplest application of phenolase inhibition and is often found at home during the time peeling and cutting the potatoes before cooking is convenient.During the intervening time , the potatoes are submerged in water, which limits the oxygen which can reach the cut potato tissue

6. Application of acids

Tit is most commonly used method for control of enzymic browning. The acids used are only those that occur naturally in tissues, particularly malic, citric, phosphoric, and ascorbic acids.

9. Boric acid and borat

Browning completely inhibits after treating it with 1.5% sodium tetraborate and 1.5% sodium metaborate.

1.8. CLASSIFICATION AND IMPORTANCE OF BEVERAGES:

Beverages' is a drink except water. Beverages can be further divided into 'Alcoholic beverages' and 'Non-alcoholic' beverages.

1.8.1. Non-alcoholic beverages

CLASSIFICATION AND IMPORTANCE OF BEVERAGES

Non-alcoholic beverages are non-intoxication drinks or s
does not have any liquor percentage or yeast is not use
alcohol during the process of fermentation.

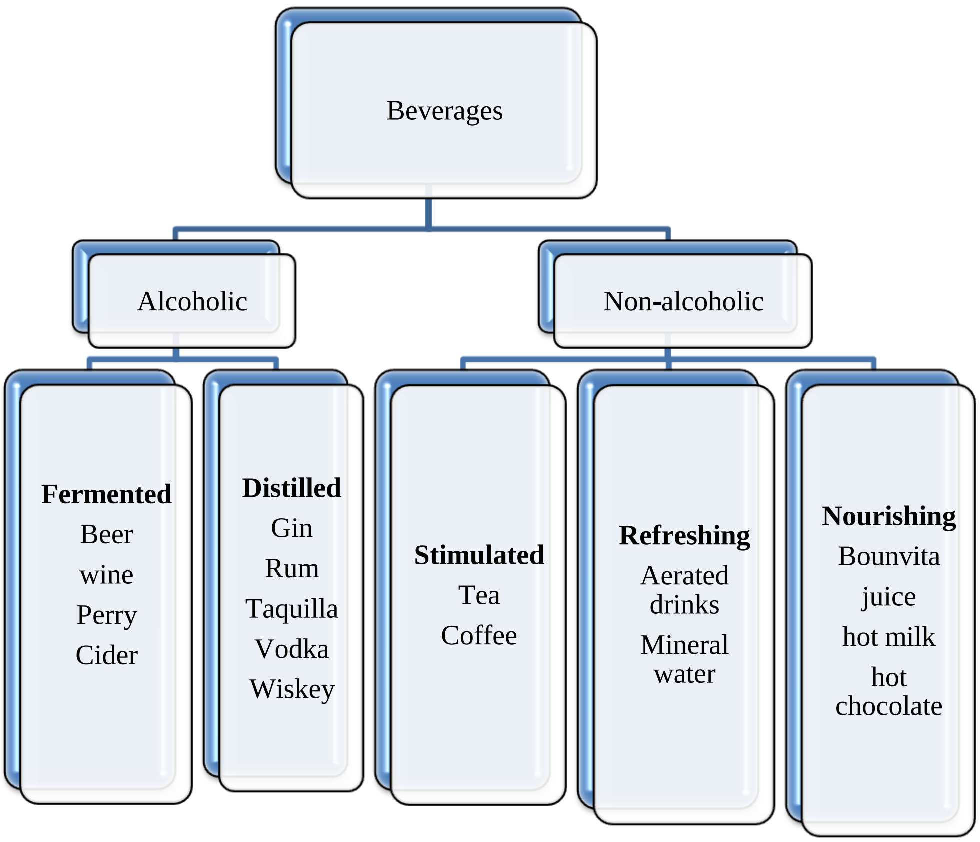
Soft drinks varies in variety like hot, chilled, canned ,bottled, or open liquids. The drinks in bottles or cans are hygienically packed, e.g. mineral waters, aerated water, juices, squashes, smoothies, syrups, shakes etc.

1.8.2. Alcoholic Beverages

An alcoholic beverage is portable liquid and contains 1% to 75% of liquor. During the production, yeast is used for fermentation of substance such as Grapes, Fruits, Rice, Grains, Barley, and Sugarcane.

Examples: Wine, Beer, Champagne, Brandy, Whiskey, Liqueur, Aperitif, Spirits, Rice Wine, Sake, and Cocktails.

Fig: Types of beverag



1.8.3. Importance of Beverage

1. Weight Loss

Certain beverages, like organic tea or green tea , improve the metabolism and give oneself a feeling of f are great to reduce curb hunger and are low in calorie c

Water can boosts the resting energy expenditure up to 30% within 10 minutes of drinking, this means that the calories which is burn while relaxing or even sleeping will burn more quickly after intake of water.

2. **Boosting Nutrients & Immunity**

The nutrient intake can be enhanced and meet the daily goals by aiding of healthy drinks. Vegetable juices and Fruit smoothies are examples of healthy beverages which are rich in nutrient and can improve a person’s immune system.

Drinks containing vitamin C, like fruit-infused water or lemon water, can slow down aging process and reduce fine wrinkles. Milk, has a great ratio of protein to carbohydrates to lipids.

3. Improving Digestion

Just by drinking warm water as a first drink in the mornir the bowel motions. Warm ginger tea can also help in spee increases the production of saliva, bile, and gastric juice b

4. Reducing Sleep Disorder

Insomnia and restlessness is problems of all ages around the world. A balanced meal which includes banana, kiwi and oats smoothie has plenty of calcium and magnesium. This helps in promoting sleep and maintaining of regular sleeping habits.

5. Keeping away from Heart Disorder

Heart-related conditions or Coronary illnesses require nutrient-rich meals and optimum dosage of medication. Timely breakfast is a secret to avoid cardiac diseases that includes fat-free foods like smoothies along with some exercise.

FOOD ADDITIVES

1.9. Food Additives

Food additives can be described as chemicals that are added to foods so they remain fresh and their colour, flavour or texture is enhanced. Food additives include flavour enhancers (such as MSG), food colorings (such as cochineal or tartrazine) or a range of preservatives.

Most of the food additives are labeled along with the other ingredients, arranged in descending order by weight.

1.9.1. Types of food additives

The different types of food additive and their uses include:

- **Anti-caking agents** – it helps the ingredients to not becoming lumpy.
- **Antioxidants** – prevent foods from going rancid or oxidizing,.
- **Artificial sweeteners** – use to increase sweetness.

- **Emulsifiers** – prevent fats to clott together.
- **Food acids** – required for maintaining right level of acid.
- **Colours** – Required in enhancing or adding colo **FOOD ADDITIVES**
- **Humectants** – keeping the foods moist.
- **Flavours** – adding of flavour.
- **Flavour enhancers** – enhancing the flavour.
- **Foaming agents** – maintain a uniform aeration made of gases in foods.
- **Mineral salts** – enhance flavor and texture.
- **Preservatives** – stop microbial multiplication and prevent food spoilage.
- **Thickeners and vegetable gums** – enhance consistency and texture
- **Stabilizers and firming agents** – the dispersion of food is maintained.
- **Flour treatment** – improves the baking quality.
- **Glazing agent** – improves appearance of food and protects food.
- **Gelling agents** – the gelling agents alters the texture of foods.
- **Propellants** – used to propel the food from a container.
- **Raising agents** –gases is used to increase the volume of food.
- **Bulking agents** –the food volume is increased without changes in energy availability.

1.9.2. Uses of food additive.

FOOD ADDITIVES

The "**Direc**t" food additives are added while the food
following objective can be acquired:

- Food additive add nutrients to the food
- It helps in processing or preparing the food
- Keeping the product fresh

- Making the food more appealing

The Direct food additives are man-made or natural.

Natural food additives include:

- Herbs and spices that add flavor to the foods
- Vinegar is used for pickling foods
- Salt, is used in preserving meats

"Indirect" food additives are substances that are not used or placed in the food they are found in food while processing or after the food is processed. These additives are found in trace amounts ofthe final product.

LEAVENING AGENT

1.9.3. Legal aspects of food additive

The use of an additive can be allowed only if it meets the fo

- It should not pose any **health risks**
- The use of added additive must be **motivated by the technical needs**
- The additive should not **mislead the consumers**.

1.10. LEAVENING AGENTS

Have you ever wondered the reason why the cakes are so soft & spongy? It is

due to the Raising agents also known as leavening agents. Leavening agent are the key ingredients that makes our cakes and other baked dishes soft and fluffy. Some of these leaving agents are biological and others are chemical. There are also some mechanical leavening techniques available.

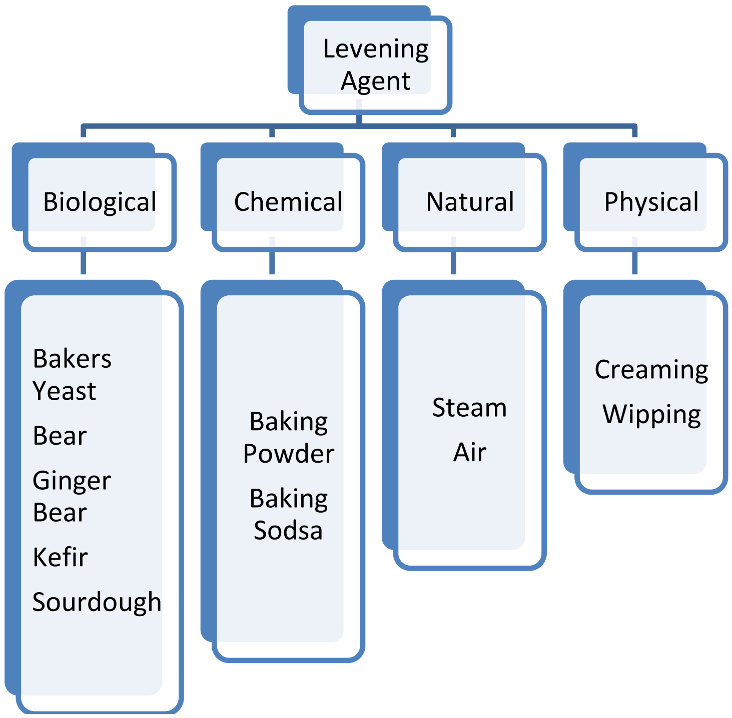
1.10.1. Function of Leavening Agents

LEAVENING AGENT

Before the dish is prepared or baked leavening agents
After resting the batter for sometime the leavening ag
the 'raised' results. The basic use of a leavening agent is to create a foaming action which helps to lighten and softens the batter. Gases produce by leavening agents is responsible to create air pockets into the batter. This air pockets are responsible for the batter to rise & become fluffy. Often, the gas that is produced by the leavening agents is either carbon dioxide or hydrogen.

1.10.2. Types of leavening agent

Fig: Types of leavening agents used in baking



LEAVENING AGENT

i. Biological leavening agents:

Biological leavening agents are those leavening agents that involve some harmless micro-organisms during the process of leavening. Yeast or Saccharomyces Cerevisiae species is an example of micro-organism that produces carbon dioxide when added into food.:

- **Baker's Yeast – Yeast Leavening**

Baker's yeast is strain of yeast that is used in baking of bread and other bakery products. The yeast can convert fermentable sugars which is present in the dough into ethanol and carbon dioxide. To activate the Baker's Yeast it is added to a warm sugar water solution. To slow down the yeast growth use salt or some fats.

- **Beer**

Bear is the most popular drink in the world after water and tea. It is formed by the fermentation of starches which is mainly derived from the cereal grains. Beer can be used as a leavening agent as due to the presence of carbon dioxide in it.

- **<u>Ginger Beer</u>**

Ginger beer is a carbonated drink which is available

non-alcoholic beverage. It can be prepared by the na sugar and yeast. It is used in baking dishes which leavening.

- **<u>Kefir</u>**

Kefir or Milk Kefir is a fermented milk drink. It is made by using kefir "grains". This drink is sour and has a mild test like yogurt. Kefir has lactic acid bacteria and yeast; therefore it can be a good leavening for cooking.

- **<u>Sourdough Starter</u>**

It is a form of bread which is made by the fermentation of dough by using naturally occurring lactobacilli and yeast. It is mixed with flour while making the dough to give the effect of leavening. Sourdough action starters slower than baker's yeast and is not suitable for bread machine.

ii. Chemical leavening agents:

Chemical leaveners are agents that are made by mixtures or compounds that can release gases when they react with each other, in presence of moisture or heat. Most of the leavening agents are a combination of salt of bicarbonate and acid. The reaction between acid and salt forms a chemical salt. Chemical leaveners are mostly used in products that require a quick fermentation effect such as in breads and cakes. Most common chemical leavening agents are:

- **Baking Powder**

Baking powder is a fine white substance that reacts in the presence of liquid and heat, it releases carbon dioxide. The activation of Baking powder is due to a built in acid.

- **Baking Soda**

It is also called Bicarbonate of Soda or Sodium Bicarbonate. It is a fine white powder which consist a mixture of alkaline salts. It can be manufactured by adding carbon dioxide to huge vats of water containing sodium chloride and ammonia. Baking Soda requires an acidic ingredient to activate it like honey molasses , fruit/fruit juice, yoghurt and lemon juice etc.

iii. Natural leavening agents:

- **Steam**

Steam at a very high temperature can be used as leaven
cooking must be capable of holding in the steam until it is set. Steam can gives the effect of leavening since it expands upon heating.

- **Air**

Air can be used as a leavening agent which is incorporated by beating the batter thoroughly with a Mechanical leavening agents.

iv. Physical/mechanical leavening agents:

- **Creaming**

Creaming is also use as leavening process. In this the sugar crystals are beaten together with solid fat. This process of leavening is mainly used in cookies.

- **Whipping or Whisking**

Whipping or Whisking is a process of leavening where egg whites or cream are whisked vigorously so that it creates a foaming action. This process is usually used in making of sponge cakes.

1.11. LETS US SUM UP

In this unit you have learnt about fruits and vegetables and its processing. Food processing is important as it prevent is from spoilage, enhance texture, color and appearance of the food. We have also learned various method of food processing and method to enhance the food products such as browning effect, food additives and leveling agent is discussed in details.

1.12. ANSWER TO CHECK YOUR PROGRESS EXERCISE

1. What do you understand by processing of food?
2. What is the main composition of food?
3. Describe the effect of cooking method on food.
4. What do you understand from browning effect? What effect it brings to the food products.
5. What is the importance of food pigment and what is its type?
6. What are the legal aspects of food additive?

7. Classify the leavening agent.