FOOD SCIENCE AND EXPERIMENTAL FOODS

M.Sc. FOOD AND NUTRITION SCIENCE

SEMESTER-I, PAPER-IV

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M.Sc. FOOD AND NUTRITION SCIENCE: FOOD SCIENCE AND EXPERIMENTAL FOODS

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FOREWORD

Since its establishment in 1976, Acharya Nagarjuna University has been forging ahead in the path of progress and dynamism, offering a variety of courses and research contributions. I am extremely happy that by gaining 'A+' grade from the NAAC in the year 2024, Acharya Nagarjuna University is offering educational opportunities at the UG, PG levels apart from research degrees to students from over 221 affiliated colleges spread over the two districts of Guntur and Prakasam.

The University has also started the Centre for Distance Education in 2003-04 with the aim of taking higher education to the door step of all the sectors of the society. The centre will be a great help to those who cannot join in colleges, those who cannot afford the exorbitant fees as regular students, and even to housewives desirous of pursuing higher studies. Acharya Nagarjuna University has started offering B.Sc., B.A., B.B.A., and B.Com courses at the Degree level and M.A., M.Com., M.Sc., M.B.A., and L.L.M., courses at the PG level from the academic year 2003-2004 onwards.

To facilitate easier understanding by students studying through the distance mode, these self-instruction materials have been prepared by eminent and experienced teachers. The lessons have been drafted with great care and expertise in the stipulated time by these teachers. Constructive ideas and scholarly suggestions are welcome from students and teachers involved respectively. Such ideas will be incorporated for the greater efficacy of this distance mode of education. For clarification of doubts and feedback, weekly classes and contact classes will be arranged at the UG and PG levels respectively.

It is my aim that students getting higher education through the Centre for Distance Education should improve their qualification, have better employment opportunities and in turn be part of country's progress. It is my fond desire that in the years to come, the Centre for Distance Education will go from strength to strength in the form of new courses and by catering to larger number of people. My congratulations to all the Directors, Academic Coordinators, Editors and Lesson-writers of the Centre who have helped in these endeavors.

Prof. K. Gangadhara Rao
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M.Sc. FOOD AND NUTRITION SCIENCE
SEMESTER-I, PAPER-IV
104FN24-FOOD SCIENCE AND EXPERIMENTAL FOODS

SYLLABUS

Course Objectives: To enable the students to:

- Acquire knowledge on Plant and Animal foods composition, processing and preservation of nutritive values.
- Understand the principles of cookery of different foods and methods of evaluation.
- Apply knowledge about different processing techniques on nutritive quality of foods.
- Apply skills in standardization of foods using different processing techniques.

UNIT-I: Introduction to Food Science

- Food Groups, Food in Relation to Health.
- General Methods of Cooking-Dry and Moist Heat Methods, Microwave and Solar Cooking, Advantages and Disadvantages, Nutrient Losses During Cooking.

UNIT II: Foods of Plant Origin

- Cereals and Millets: Starch- Structure, Characteristics of some food starches. Gelatinization, Factors effecting gelatinization. Modified food starches-Applications.
- Pectin and Gums: Functional roles in food products.
- Baking process: Cereal flours, Flour mixes -dough and batter, Leavening agents-Applications
- Pulses and Legumes: Composition, Toxic constituents, Processing, Effect of cooking.
- Vegetables and Fruits: Classification, Composition, Pigments and Flavors constituents - Cooking effect, Browning reaction.

UNIT III: Foods of Animal Origin

- Milk: Composition, Kinds of Milk and Functional Properties of Milk.
- Egg: Structure, Grading, Quality and Functional Properties of Eggs.
- Meat and Poultry: Structure, Muscle composition, Postmortem Changes, Heat-induced changes in meat, Tenderness - Tenderizers.
- Fish and Marine Foods: Classification and Composition, Selection and Cooking.

UNIT IV: Sugars and Fats

- Sugars, Sugar Crystals and Confections: Types of Sugars and sugar syrups, Sugar Cookery, Crystallization of sugars, Confectionery-Types, Raw Materials and Their Role, Indian Confectionery.
- Fats and oils: Sources, Composition, Absorption, Functional Properties of Fat, Rancidity.

UNIT V: Sensory Evaluation

- Sensory Attributes of Food Quality and its Characteristics.
- Requirements to Conduct Sensory Evaluation-Sensory Panel, Preparing and Presenting Samples for Testing, Panel booth.
- Sensory Tests-Analytical and Affective Tests.

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Course Outcomes: After completion of this course, students will be able to:

CO1: Learn about changes occur in food and nutrients during cooking.

CO2: Understand the structure, characteristics and processing of cereals and millets.

CO3: Learn about nutrient composition of milk, egg, meat and fish.

CO4: Knowledge on sugar cookery and confectionary.

CO5: Acquire skills in sensory evaluation techniques.

(104FN24)

M.Sc. DEGREE EXAMINATION, MODEL QUESTION PAPER
FIRST SEMESTER
PAPER-IV: FOOD SCIENCE AND EXPERIMENTAL FOODS

Time: Three hours **Maximum: 70 marks**

Answer ONE Question From Each Unit **5 × 14 = 70M**

Each Question Carries 14 Marks.

UNIT-I

1 Write in detail about food groups and dry heat cooking methods.

OR

2 Write about advantages and disadvantages of moist heat cooking methods.

UNIT-II

3 Explain about composition and toxic constituents of pulses.

OR

4 Discuss about pigments and browning reactions in fruits and vegetables.

UNIT-III

5 Write about egg structure and functional properties.

OR

6 Write in detail about classification, selection and cooking of fish.

UNIT-IV

7 Write in detail about types of sugars and sugar syrups and explain Indian confectionery.

OR

8 Discuss about functional properties of fat and rancidity.

UNIT-V

9 Explain about attributes of food quality and its characteristics.

OR

10 Write about Analytical and Affective tests in sensory evaluation of food.

CONTENTS

LESSON-1

INTRODUCTION TO FOOD SCIENCE

OBJECTIVES:

After studying this lesson, you should be able to:

- To know about concepts of Food Science
- To study about Food groups
- To study about foods in relation to health

STRUCTURE:

1.1 INTRODUCTION:

For nourishment, sustenance and well being, human beings consume foods in processed, semi processed or cooked forms. Life cannot be lived without adequate nourishment. Man needs good food for growth and development and to lead a healthy life. Food is the fuel for any living organism. Food has an important part in maintaining an individual's nutritional status. This is directly related to health status also. Components in foods are absorbed by body organs and they are assimilated for normal functioning. Examples of such components are cereals, legumes, fruits and vegetables, livestock produce and sea foods. Plantation crops also come under food like tea and coffee. The below are the examples of foods in different categories.

Table 1.1 Categories of foods

Cereals	Wheat, Sorghum, Rice and millets
Legumes	Red gram, black gram, green gram and beans
Horticultural Produce	Fruits, vegetables, spices, condiments
Livestock	Meat, egg, milk
Sea Food	Fish, prawns, crabs
Plantation CROPs	Coffee and Tea

Source-Food Science, B.Srilakshmi, Sixth edition.

Some foods can be taken in raw form and some have to be compulsorily cooked to remove anti nutrients. Food is very essential for living and is the real essence of life. Human beings started experimenting on different forms and tastes and developed culinary art. Later people developed interest and became famous in terms of food innovations.

Food Science: It is the discipline in which the biological and physical sciences and engineering are used to study the nature of foods, deterioration causes and principles underlying food processing.

Food Technology: It is the application of Food Science to the selection, preservation, processing, packaging, distribution and use of safe nutritious and wholesome food.

1.2 CONSTITUENTS OF FOODS:

Major constituents in foods are carbohydrates, fats, proteins, dietary fibre, energy and water. Food sources of the above components are given below.

Table 1.2.1 Sources of Carbohydrates

Carbohydrate	Sources
Monosaccharides	Milk, Fruits, Honey, Cereals, Vegetables
Disaccharides	Beet sugar, Molasses, malt and mushrooms
Sugar Alcohols	Cherries, Fruits and Vegetables
Sugar Acids	pectin
Short chain carbohydrates	Kidney beans, lentils and beans
Polysaccharides	Processed foods, cooked starches, bran

Source-Food Science, B Srilakshmi, Sixth edition

Table 1.2.2 Sources of Fatty acids

Type of Fatty Acid	Sources
Saturated fatty acids	Butter, Coconut oil, vegetable oils
Unsaturated fatty acids	Olive oil, beef fat, fish oil, Canola oil, avocado
Monounsaturated fatty acids	Olive oil, Rape seed oils
Polyunsaturated fatty acids	Vegetable seed oils, shell fish and algae
Long chain fatty acids (saturated)	Butter, lard, peanut oil
Medium chain fatty acids (Saturated)	Butter, Coconut oil
Short Chain fatty acids (Saturated)	Butter

Source-Food Science, B Srilakshmi, Sixth edition

Table 1.2.3 Sources of Proteins

Proteins	**Occurrence**
Simple Proteins - Globular	Egg albumin, Myosin, Serum albumin
Fibrous Proteins - Scleroproteins	Skin, Tendons, Bones, Hair
Conjugated Proteins	Chromosomes, nucleoli
Primary Derived Proteins	Coagulated egg white
Secondary derived Proteins	Proteoses, Peptones, Polypeptides

Source-Food Science, B Srilakshmi, Sixth edition

Table 1.2.4 Sources of Fibre

Fibre	Sources
Insoluble Fibre	Whole wheat flour, Bran, Mature root vegetables
Soluble fibres	Apples, Guavas, citrus fruits, carrots, Gum arabica

Source-Food Science, B Srilakshmi, Sixth edition

Nutritional value and taste are the most important properties and are relatively easier to evaluate and also the effects are more. Sensory evaluation is the most important property in terms of appearance, smell, taste and texture. The above properties are influenced by below factors.

1) Physical properties of foods
2) Geometrical properties
3) Size and shape
4) Volume and density measurement
5) Colour and gloss
6) Rheological Properties
7) Thermal properties

Physical Properties of Foods: The properties that quantify food by physical means rather than chemical means.

Geometrical properties: To check the properties of size, shape, volume, density and surface area in terms of homogenous units. These are mostly related to structurally heterogeneous foodstuffs. Categories of sizes include round, oblate, oblong, conic, elliptical, truncated, ribbed etc. For description shape, sphericity is used.

Size: This is determined by sieves or screen openings, through which product will or will not pass. It also measures the diameter or length of the product.

Volume, density and surface area: While measuring the above properties, proper control of temperature should be maintained. Graduated cylinder method, Pycnometer, commercial density meters, water displacement methods are used to measure.

Density is measured by floatation in liquids or salt solutions at different densities. In peas, lima beans and potatoes, density is an indirect measurement of texture also. To remove defective materials and extraneous materials, separation by floatation is used.

Types of Density:

1) True Density
2) Substance Density
3) Particle Density
4) Apparent Density
5) Bulk Density

Surface area: Surface area is directly related to heat transfer. Areas of axial or longitudinal cross sections can be measured especially in fruits.

Optical properties: These are measured by using a spectrophotometer which measures light in both reluctance and transmittance. Colour and gloss are two properties under this category. Transmitted lights can be used to detect water cores in apples.

Colour: This is the most important factor that can alert the consumer to check quality defects. It checks with flavour enhancements also. Reflectance, Dominant wavelength and purity are the base principles for spectrophotometric methods. Hunter color lab calorimeter is used. L defines the lightness, a, the red-green lines and b the blue-yellow lines.

Gloss: The surface appearance is termed as glossy and dull is the first aspect inspected by people. Gloss is checked with apples, cucumbers, cherries, cherries, oranges, beans etc., It is the Psychological attribute of surfaces associated with spectrum. The reflection of the spectrum varies from surface to surface and is the true measure for gloss.

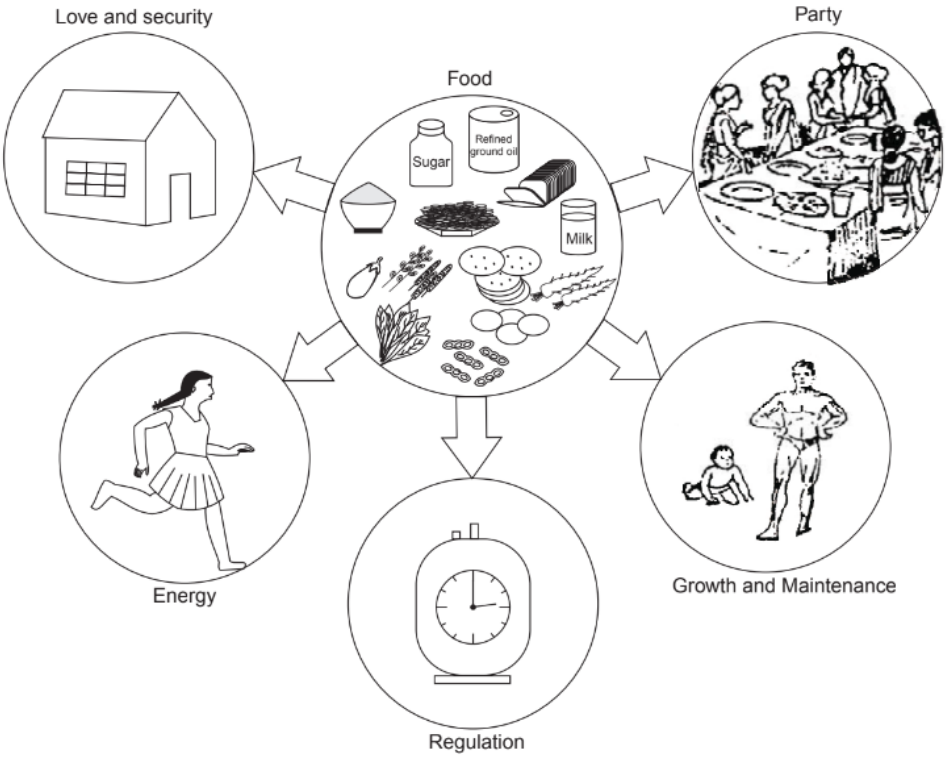

Figure 1.1 Functions of Food

Reference-Food Science by Sumati R

Rheological Properties: These are also known as flow behaviour properties of foods. Due to the complex nature of foods, rheology is also complex. The classes of rheology such as fundamental tests are given as follows.

1) Modulus of elasticity
2) Poisson ratio
3) Relaxation time
4) Shear modulus

5) Puncture force
6) Extrusion energy

Conditions for conducting fundamental tests are quasi static and dynamic conditions. Since foods are viscoelastic, time dependent and time independent measurements are used. Foods that have no shape are known as fluid foods

1.2.1 FACTORS AFFECTING STATE OF FOODS:

1) Structure and composition
2) Water content
3) Flow behaviours
4) Viscoelastic behaviours
5) Shear thinning properties
6) Shear thickening properties

THERMAL PROPERTIES OF FOODS

1) Specific heat
2) Enthalpy
3) Thermal conductivity
4) Thermal diffusivity
5) Heat transfer coefficient.
6) Melting/freezing point
7) Latent heat
8) Heat of respiration
9) Heat of adsorption
10) Coefficient of thermal expansion
11) Dielectric constant
12) Emissivity and absorptivity
13) Radiation heat transfer

1.3 CLASSIFICATION AND FUNCTIONS OF FOOD:

Classification of food is based on following properties

1) Origin
2) Functionality

3) Chemical Composition
4) Nutritive value
5) Mass
6) Chemical Nature

I. Based on Origin, foods are classified as follows

1) Plant Foods
2) Animal Foods

II. Based on functionality of foods, following classification is seen

1) Energy giving foods - Carbohydrates (Cereals, fats, sugar fats)
2) Body building foods - Proteins (Pulses, milk, meat, chicken)
3) Regulatory Foods - Vitamins (Fruits and vegetables)
4) Protective foods - Minerals (Fruits and vegetables)

III. Based on chemical composition, foods are classified as follows

1) Organic
2) Inorganic

IV. Based on Nutritional composition, foods are categorized in to 12 components

1) Cereals and pulses
2) Nuts and oilseeds
3) Vegetables
4) Green leafy vegetables
5) Roots and tubers
6) Other vegetables
7) Fruits
8) Milk and milk products
9) Meat, Fish, Poultry and eggs
10) Fats and oils
11) Sugar and Confectionery
12) Spices and condiments

V. Based on the mass of the food, foods are classified as follows

1) Macronutrients
2) Micronutrients

VI. Based on the chemical nature of the food, foods are classified as follows

1) Carbohydrates
2) Proteins
3) Fats
4) Vitamins
5) Minerals
6) Dietary Fibre
7) Water

1.3.1 BASIC FOUR FOOD GROUPS:

Table 1.3.1.1 Basic Four Suggested by ICMR

Food Groups	Nutrients
Cereals, Millets, and Pulses	Energy, Protein, Invisible fat, Thiamine, Folic acid, Riboflavin, Iron, and Fibre
Milk and Animal Products	Protein, Fat, Riboflavin, Calcium, iron
Vegetables and Fruits	Riboflavin, folic acid, calcium, fibre, iron, Carotenoids, Vitamin C
Oils, Fats and Nuts	Energy, Essential Fatty acids, fat soluble vitamins, Protein and Omega fatty acids

Source-Food Science, B Srilakshmi, Seventh edition

1.3.2 BASIC FIVE FOOD GROUPS:

Table 1.3.1.2 ICMR Basic Five Food Groups

Food Group	Main Nutrients
I. Cereals, Grains and Products	Energy, Protein, Invisible fat, Vitamin B1, Vitamin B2, Folic acid, Iron, Fibre
II. Pulses and Legumes	Energy, Protein, Invisible fat, Vitamin B1, Vitamin B2, Folic acid, Calcium, Iron, Fibre
III. Milk and Meat Products	Protein, Fat, Vitamin B12, Calcium, Protein, Fat, Vitamin B2
IV. Fruits and Vegetables	Carotenoids, Vitamin C, Fibre

Vegetables	Invisible fats, Carotenoids, Folic acid Calcium, Iron, Fibre
Other vegetables	Carotenoids, Folic acid, Fibre, Calcium
V. Fats and sugars	Energy, Fat, Essential Fatty acids
Sugars	Energy

Source-Food Science, B Srilakshmi, Sixth edition

Table 1.3.1.3 Food Groups with Examples

Food Group	Examples
Cereals, Grains and Products	Rice, wheat, ragi, Bajra, Maize, jowar, Barley, Rice flakes, Wheat Flour
Pulses and Legumes	Bengal gram, Green gram, Black gram, Red gram, lentils, Cowpeas, peas, Rajmah, Soybeans, Beans
Milk Products	Milk, curd, Skimmed milk, Cheese
Meat Products	Chicken, liver, fish, eggs
Fruits	Mango, Guava, Ripe tomato, Papaya, orange, sweet lime, Water melon
Vegetables	Amaranth, Spinach, Drumstick leaves, Coriander leaves, Mustard leaves, fenugreek leaves
Other vegetables	Carrots, Brinjal, Ladies finger, Capsicum, Beans, Onion, Drumstick, Cauliflower
Fats	Butter, Ghee, Hydrogenated oils, Cooking oils like groundnut, Mustard, Coconut
Sugars	Sugar, Jaggery

Source-ICMR, Basic Five Food Groups

1.4 FOODS IN RELATION TO HEALTH:

A balanced diet is always a right choice for a healthy life. It includes foods in adequate amounts and correct proportions to meet dairy requirements of all macro and micronutrients. It promotes good health and provides a safety margin or reserve of nutrients to withstand short times of deprivation, when a diet lacks nutrients. Balanced diet should meet the

Recommended Dietary Allowances (RDA) of any individual, so that safety margin is attained for food safety. Hence, the

Recommended Dietary Allowances = Requirements + Margin of safety.

A balanced diet takes care of the following aspects.

1) Includes a variety of food items.
2) Meets the RDA for all nutrients.
3) Includes nutrients in correct proportions.

Table 1.4.1 Food in Relation to Health

Nutrients	Sources
Energy, Protein	Fat, Sugar, Cereals, pulses, egg and meat
Calcium	Milk, green leafy vegetables, gingelly seeds
Iron	Liver, green leafy vegetables, Rice flakes, Jaggery
Vitamin-A	Liver, egg yolk, butter, carrots, green leafy vegetables
Thiamine	Yeast, Outer layers of cereals, Pulses and nuts
Niacin	Ground nut, whole cereals, pulses
Vitamin B6	Meat, liver, vegetables, whole cereal grains
Folic Acid	Fresh green leafy vegetables, ladys finger, cluster beans
Vitamin - B12	Yeast, fermented foods
Vitamin - C	Citrus fruits, amla, guava
Vitamin - D	Eggs, flesh foods, sunlight

Source- Food Science, B Srilakshmi, Seventh edition

Food Pyramid is also one of the concepts which details control of foods, portion sizes and frequency of consumption of different nutrients. Food pyramid helps us to plan a proper nutritious meal for every day based on the daily requirements for human beings.

According to ICMR, Food pyramid is the concept that suggests the amount and types of foods to be included in daily diets

1) Eat Sparingly - processed and ultra processed foods
2) Eat Moderately - Meat and Meat products, beverages etc.,
3) Eat liberally -Fruits, vegetables and Green leafy vegetables
4) Eat Adequately - Pulses, Legumes and millets etc.,
   - Exercise regularly and be physically active for proper functioning of the body organs and for mental well being.
   - Abstain from drinking alcohol
   - Say No to Tobacco

Table 1.4.2 Deficiency Diseases

Nutrients	Deficiency diseases
Energy, Protein	Underweight, Marasmus, Kwashiorkor
Calcium	Rickets, Osteomalacia, tetany
Iron	Anaemia
Vitamin-A	Night Blindness
Thiamine	Pain in the calf muscle, weakness of heart muscle
Niacin	Dementia, Diarrhoea, Dermatitis
Vitamin B6	Anaemia, angular stomatitis
Folic Acid	Megaloblastic Anaemia
Vitamin - B12	Pernicious Anaemia
Vitamin - C	Bleeding gums
Vitamin - D	Rickets, osteomalacia

Source-Food Science, B Srilakshmi, Seventh edition

1.5 SUMMARY:

Food is an essential part of life. It is the fuel for the human body. Like oxygen, food supports us in terms of well being and life span. Foods are categorized into macronutrients and

micronutrients. Foods are packed with nutrients, which helps for regular biological processes in the human body. Macronutrients are required in larger quantities and micronutrients are required in smaller quantities. Based on age groups, nutrient needs differ. It is proven that many foods are anti-inflammatory and antibiotic in nature. However food sometimes acts as a medicine.

1.6 TECHNICAL TERMS:

Food, Food Science, Food Technology, Basic five groups, Recommended Dietary Allowances, Nutrients etc.,

1.7 SELF ASSESSMENT QUESTIONS:

1) Write about food constituents.
2) What are the basic four food groups?
3) What are the basic five food groups?
4) How is food related to health?

1.8 REFERENCE BOOKS:

1) Food Processing Technology Principles and practice 2nd edition by P.Fellows, Woodhead Publishing, Limited.
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Dr. B. Babitha

LESSON-2

GENERAL METHODS OF COOKING

OBJECTIVES:

After studying this lesson, you should be able to:

- To know about methods of cooking.
- To study about advantages and disadvantages of cooking.
- To study about nutrient losses during cooking.

STRUCTURE:

2.1 INTRODUCTION:

Cooking food is not only a hobby; it is an essential practice to make food edible. Some foods can be taken raw like fruits, but some have to be compulsorily cooked to increase palatability factor. Food behaviour after application of heat is very different. Some foods exude water, some food concentrates solids, some foods absorb water etc., Each and every food will have a separate cooking method, which makes it edible and tasty. Cooking should be learned and practiced thoroughly, so that every cuisine comes at its best. In industries, cooking is very essential especially while preparing RTE foods.

Food contains components like proteins, fats, carbohydrates, water, pigments, colours, flavours etc., The reactions of all these components upon heat application is very important to produce quality foods. Ingredients when mixed with each other, their rheology changes to a larger extent. Correcting cooking faults, ingredient proportions and cooking temperatures are an hour of need for better production.

2.2 OBJECTIVES OF COOKING:

1) Food Quality Improvement
2) Taste Enhancement
3) Destruction of Microorganisms
4) Improving digestibility of foods
5) Increase in consumption of foods
6) Increase in availability of nutrients
7) Increase in antioxidant values
8) Concentration of nutrients
9) Minimizing Pesticide residues

2.3 PHYSICAL AND CHEMICAL REACTIONS OF FOOD:

Carbohydrates:

These are present in the form of sugars in fruits, root vegetables, grains, beans, nuts etc., Two important reactions induced in carbohydrates are caramelization and gelatinization. Browning of sugars at higher temperatures is known as caramelization. It is due to formation of pyrazine and imidazole in the food system. Examples are sauteed vegetables and bread crusts. When starches absorb water, they swell into a thick mixture known as gelatinization. Examples are pastries and sauces.

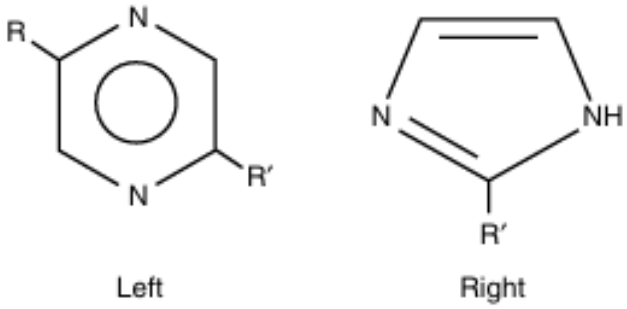

Figure 2.3.1 Pyrazine and Imidazole Formation During Caramelization

Fruit and Vegetable Fibre:

This gives firmness and texture to plant based products. This is not digestible in nature. When we break down the fibre in fruits and vegetables, softness is observed. In the same line, sugar increases firmness. Hence certain fruits are cooked in sugar and preserved. Along with sugar, baking soda and other alkalis may give softness to fibre. It is not used with vegetables, as baking soda creates a slurry or paste form in the food system.

Proteins:

It is the major part of animal based foods like meat, fish, eggs, milk etc., This is seen in very small amounts in certain grains but high in pulses and legumes. Amino Acids are the building blocks of proteins. These are seen in the form of coils and will unwind upon application of heat. This is known as protein denaturation. After denaturation, amino acids will attract random compounds to all other components and form bonds. This is termed as coagulation. These are solid and firm. After giving higher temperatures, proteins become firm and lose moisture. They will be in dried form and with strong texture. For most of the foods, coagulation temperatures will be between (71°C to 85°C).

Protein rich foods contain smaller amounts of carbohydrates. Near to 154°C, amino acids in protein chains react with carbohydrates and form brown compounds. This is known as the maillard reaction. This is seen only on the surface of the food. This proves that the surface of food imbibes more heat than the inside core. Other important tissues called connective tissues are also seen. These will dissolve under low temperatures in the presence of moisture. Acids can speed up dissolution of proteins especially in case of tough meats, texturized protein products etc., Vinegar can be used industrially for more coagulation.

Fats:

These are important mediums for cooking, especially frying and grilling. These can be solid or liquid at room temperatures. Fats in liquid form are known as oils. Fats in solid forms are known as hydrogenated fats and lard. Based on differences in melting points, some fats serve as solids and some as liquids. Fats deteriorate fast when heated. They release smoke at higher points and the phenomenon is known as smoke point. Based on the nature and origin of fat, the smoke point differs. Fats are carriers of flavours. Fats contain fat soluble vitamins in them, when fats are lost from food, vitamin loss is seen.

Minerals, Vitamins, Pigments and Flavour Components:

These are important nutrients essential for the human body. Pigments and flavours are also seen which makes food more palatable. These are micro nutrients and are essential for body processes. Hence while cooking, all the nutrients have to be preserved. Some are soluble in water and some are soluble in fat. These are most heat sensitive and may be destroyed by long cooking. Best cooking method preserves most of the vitamins and minerals in food is boiling

Water:

All foods are made up of water. Water in food exists in three states known as, ice, liquid and gas. At sea level, at 0°C liquids turn to solids, at 100°C it turns to vapour. Boiling is the phenomenon where moisture in foods escape in the form of vapour. Evaporation occurs when water is turned to gas at lower moistures. It is responsible for drying of foods. It is the carrier for most of the nutrients. Upon addition of salt or sugar, freezing point can be lowered and boiling point can be raised.

HEAT TRANSFER METHODS:

Heat will be transferred in three modes. They are given below:

1) Conduction
2) Convection
3) Radiation

1. Conduction: Transfer of heat through solids is known as conduction. Some solids are good conductors of heat and some are bad conductors of heat. Ceramics and iron will retain heat and some cannot retain heat such as copper.

2. Convection: Heat transfer in the form of liquids and gases is known as convection. Examples are convection of air and liquids.

3. Radiation: when electromagnetic waves are passed inside the food, they lose energy in the form of heat. This phenomenon is known as radiation. Infrared waves and microwaves are used for the radiation process.

Heat transfer may happen in different ways. They are heat transfer in parallel and heat transfer in series. For perfect heat transfer, the difference of temperature is a primary thing, where heat is transferred from hot surface to cold surface.

Figure 2.3.2 Modes of Heat Transfer
(Reference: Search Engine Google-The learning apps)

2.4 METHODS OF COOKING:

Based on the nature of foods, cooking methods are employed at different stages of processing. Texture of the food is the most important factor which determines the choice of cooking process. For firmness and delicacy, the following methods of cooking can be employed.

1. **Moist-heat methods:**

   Heat is conducted to the food by water based liquids or directly water.

   Example: Sauces and Stews. Steam also can be used as a source of heat.

2. **Dry-heat methods**:

   Heat is conducted without moisture.

   Example: Hot metal, radiation or hot fat.

DRY HEAT METHODS:

These methods employ cooking without moisture, i.e., heating by dry hot air, hot metal, radiation and hot fat. Dry heat methods are categorized in to two classes

1) Withfat
2) Without fat

Major Dry heat methods of cooking are given below

1) Baking
2) Roasting
3) Grilling

2.4.1 BAKING:

Definition

It is the cooking of food in an oven by the action of dry heat. Here the action of dry heat is modified by steam.

Purpose of Baking:

1) Baked foods are easily digestible
2) Baked foods are highly palatable
3) Safe to eat
4) Baked goods are with good colour and texture
5) Baked goods are enjoyable and variety foods

Effects of Baking:

- ➢ Chemical action is seen in baking within the ingredients like sugar, baking powder, yeast etc.,
- ➢ Mixing of all the dry and wet ingredients and activating the baker's yeast are the major key factors.
- ➢ Preheating should be done for the conventional oven to correct the starting temperatures.
- ➢ For even heat circulation, mix should be placed in a tray evenly.
- ➢ Greasing or lining with any food lubricant is essential to remove finished food easily.

- ➢ Ingredients which are sensitive in heat should be properly identified to avoid blackening or burning of crust.
- ➢ Two types of baking are seen like dry baking and baking with increased humidity.

Dry Baking:

In this method, steam arises from water present in food and combines with dry hot air in the oven. The energy generated in this process is used to bake the food. Examples: Cakes, Pastries, Baked potatoes etc.,

Baking With Increased Humidity:

In this method, a bowl of water is placed inside the oven, so that steam is generated and injected into the food. The steam is used to bake the food. It improves the baking quality also.

Baking With Heat Modification:

Here, the food is baked in a special container, so that overcooking will not happen. Examples: egg custard.

Advantages of Baking:

1) Variety of savory food is prepared
2) Eye appealing food is obtained
3) Foods with quality are obtained
4) Bulk cooking reduces time
5) Uniform Degree of cooking
6) Appealing colour is seen
7) Effective temperature controls
8) Ease of processing
9) Economical to use

General Rules for Baking:

1) Preheating of oven is compulsory
2) Measuring and weighing apparatus should be accurate in nature
3) Greased and lined trays and moulds are essential to avoid burning
4) Close the oven doors while baking to avoid fire accidents
5) Usage of thick oven mats which are dry in nature
6) Checking the capacity of trays and ovens
7) Usage of gloves while loading and removing the baked food

8) Measuring cups should be used to maintain weight of ingredients used for baking
9) Oven thermometer usage is very much essential to check temperatures
10) Baking tins should be of food grade, to avoid metal poisoning
11) Sieving of all ingredients is mandatory for uniform baking
12) Cooling of baked goods is necessary before packing
13) Baking should be done based on capacities of ovens
14) Center rack of oven should be used for baking for proper baking
15) Bread and other fermented baked goods need proofing time, which has to be maintained for good volume of products
16) Igniting materials should not be placed near to ovens, to avoid fire accidents
17) Improper mixing of ingredients gives lumpy and defective products
18) Usage of Moisturizing agents increases the volume and softness of baked goods.
19) Proper care must be taken that spillage should not occur inside the ovens

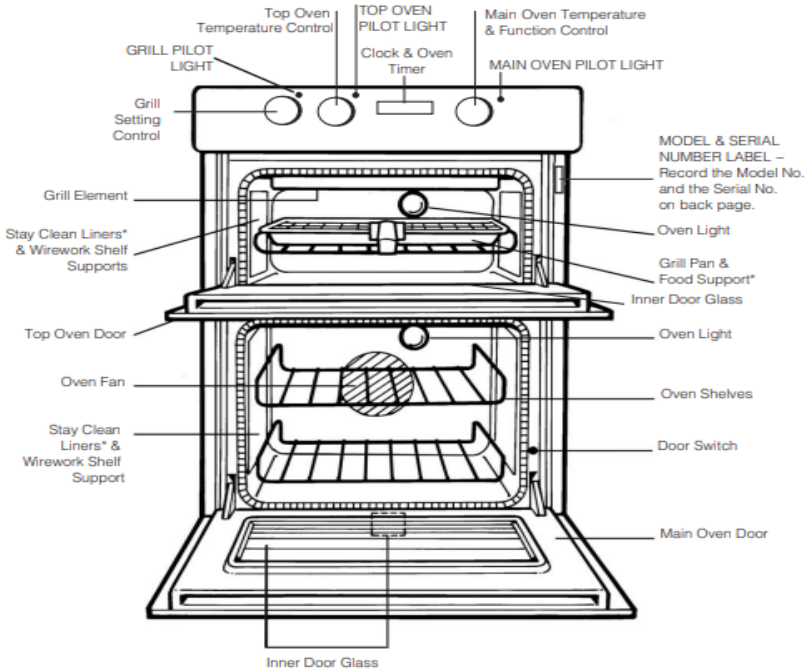

Figure 2.4.1.1 Electrical Double Oven

(Reference: User manual for bakery ovens, EU)

2.4.2 ROASTING:

It is defined as cooking food by the use of radiant heat like on spit, oven or open fire. Roasting can be done in the oven also with fat or without fat. It is the combination of convection and radiation.

There are four types of roasting methods for foods, which are given below.

1) Oven Roasting
2) Spit Roasting
3) Pot Roasting
4) Tandoori Cooking

Oven Roasting:

This is the method which implies hot convection air which is responsible for cooking food. Heat is conducted through trays and is enough to change the crust colour of foods

Examples:

- Potatoes Crisps (Golden Brown)
- Chicken cuts
- Whole meats
- Beef
- Vegetables
- Briskets
- Pork

Figure 2.4.2.1 Oven used for Roasting
(Reference-Borosil, Food Equipments)

Spit Roasting:

Here, open fire or live charcoal (spit) is used. Food is cooked by radiant heat and convection of air is also seen. This methods improves quality of food and gives own distinct flavour and texture along with colour

Examples:

- ➢ Whole meats
- ➢ Poultry meats

- Sweet corn
- Plain Corn
- Beef
- Briskets
- Cut Meats
- Crab Meats
- Fiber rich vegetables
- Kebabs

Figure 2.4.2.2 Spit Roasting

(Reference-Jared Ingersolls guide, food roasting)

Pot Roasting:

This is the method where food is cooked on a bed of root vegetables with covered lids. Moist steam is trapped under the lining of the closed lid and is used to cook food. This is not true roasting. These methods retain maximum flavour of foods. This is known as POELE.

Figure 2.4.2.3 Vessels for Pot Roasting
(Reference: Search Engine-Google)

Tandoori Cooking: This cooking is seen in a clay oven called tandoor. Dry heat is used in this method. Source of heat is at the base of the oven and clay radiates heat evenly. The food is marinated for 20 min to 2 hr based on type and nature of food Example: Meat, Fish and Poultry. The marinated foods are placed vertically and cooked. Naans and rotis are slapped into the walls of the oven. Temperatures will be above 375 C.

Figure 2.4.2.4 Clay Tandoor

(Reference: MN Tandoors Manual for tandoor baking)

Advantages of Roasting :

1) Tender and succulent meats
2) Flavour enhancement in foods
3) Energy and temperature control
4) Monitoring ease for cooking
5) Easy processing methods
6) Minimum risk of fire.

2.4.3 GRILLING

This is the method where radiant heat is used for cooking. This is also known as broiling.

Types of grilling are given below:

1) Over heat
2) Under heat
3) Between heat
4) Barbecuing

Over Heat: Hot grill bars are used for cooking. These are pre-heated and brushed with oil. If oil is not greased, foods will stick to each other. Thickness of food and temperature of grills are the key factors.

Under Heat: Keeping the source of heat over the food will cook the food. Example is salamander cooking to retain nutrients. Salamander heaters are used and is old cooking process

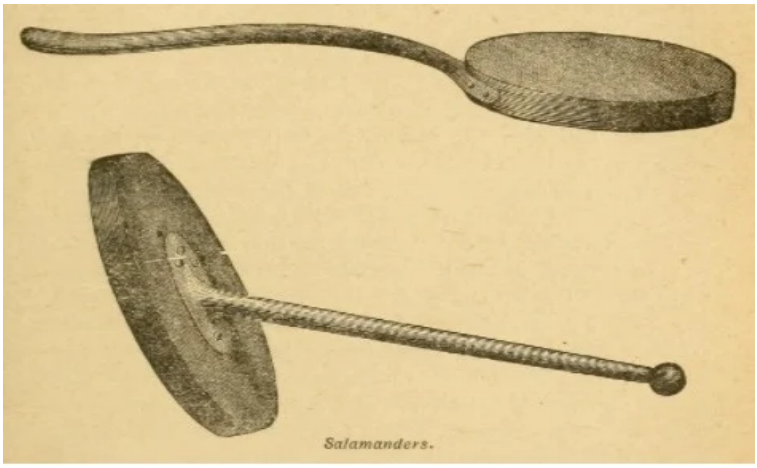

Figure 2.4.3.1 Salamander heaters

(Reference: Practical American Cookery, 2016)

Between the Heat: Electrical grill plates and bars are heated and meat is placed on them. This method is used for cuts of meat.

Figure 2.4.3.2 Grilled Pans

(Reference: Search Engine-Google)

Barbecuing: here fierce heat is employed along with solid fuel. Gas, charcoal and wood are also used. Food is placed on bars releasing smoke. Barbecue sauce is used for brushing the meat for more flavour.

Advantages of Grilling:

1) Fast cooking process
2) Distinct appealing sensory attributes

3) Temperature control
4) Cooking is visible
5) Easy Handling

Figure 2.4.3.3 Portable charcoal BBQ

(Reference: Search Engine-Google)

2.5 NUTRIENT LOSSES DURING COOKING:

All the heat sensitive nutrients especially vitamins may be lost during dry cooking. Amino acid loss is also one of the phenomena that occurs during dry cooking. Loss of ascorbic acid in vitamin C rich fruits and vegetables is noticed during cooking. Since ascorbic acid is a vitamin which is readily lost, emphasis should be on retention of ascorbic acid. The presence of this vitamin directly gives the count of other essential vitamins like vitamin B. Hence it can be assumed that if ascorbic acid is retained in the food during cooking, other vitamins also may be retained. This is quite contrary in the case of dried legumes. These are rich in vitamin B and are devoid of Ascorbic acid. No method preserves the total amount of nutrients in the food. But serving soon after cooking may sometimes benefit the consumer. This is due to minimum physical destruction of vegetables.

2.6 SUMMARY:

All the methods described have the capacity to improve flavour and texture of food. Uniform and bulk cooling can be achieved especially in baking. No special skills are required to operate. Grilling is also a quick method of cooking. Products with improved flavour are seen. Very less fat is required for cooking. No much loss of nutrients is seen except for amino acids. However, constant attention is required to prevent charring of foods. Based on the nature of the foods, cooking methods should be employed to prevent nutrient losses.

2.7 TECHNICAL TERMS

Baking, Roasting, cooking, Grilling, Conduction, Convection, Radiation, Nutrients

2.8 SELF ASSESSMENT QUESTIONS:

1) What are methods of cooking?
2) What are the types of dry heat methods?
3) Write about nutrient losses in foods while cooking?
4) Define cooking and what are physical and chemical reactions of foods while cooking.
5) What are the advantages and disadvantages of cooking?

2.9 REFERENCE BOOKS:

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LESSON-3

MOIST HEAT METHODS OF COOKING

OBJECTIVES:

After studying this lesson, you should be able to:

1) To know about Moist heat methods of cooking.
2) To study about advantages and disadvantages of moist heat methods of cooking.
3) To study about nutrient losses during cooking.

STRUCTURE:

3.1 INTRODUCTION:

Cooking methods are different for different foods based on their moisture methods. Fruits and vegetables have more moisture. They require less heat for cooking. Meats have higher connective tissues and tissues have to be softened while cooking. This requires higher temperatures for cooking. Tender and juicy meats are also seen which require less heat. Based on the final requirement of the consumer, with respect to sensory attributes like flavour, appearance, cooking methods are employed.

3.2 CLASSIFICATION OF COOKING METHODS:

Based on the source of heat, cooking methods are categorized into following classes.

1) Moist heat methods
2) Dry heat methods

1) Moist-heat Methods:

In this, heat is conducted through water like stock, sauces and steam.

2) Dry-heat methods

In this, heat is conducted by dry air like hot air, hot metal, radiations etc., These methods can be with fat or without fat

3.3 MOIST HEAT METHODS OF COOKING:

The following are the moist heat methods of cooking.

1) Boiling
2) Blanching
3) Poaching
4) Steaming
5) Vacuum Cooking in Pouch
6) Pressure cooking
7) Stewing
8) Braising

3.3.1 Boiling:

Cooking in water or any other liquids with solute, at their boiling point is known as boiling. Different types of liquids may be used like water, milk, stews etc., Boiled food will have pleasant taste, good flavour, texture and is easy to digest and highly palatable. Food can be boiled directly in boiling liquid, re boiled and then cooked in low flame. This type of boiling is known as simmering. Another method is to cover food with liquid at a lower temperature and then cook slowly.

Examples:

- ➢ Liquid simmering of fish
- ➢ Sliced carrots
- ➢ Sliced onions
- ➢ Green vegetable stalks
- ➢ Spice stews etc.,
- ➢ Boiled meats

Figure 3.3.1 Boiled Vegetables (Reference-New York Times, 2020)

Effects of Boiling:

1) Tenderizing tough fibers
2) Solubilizing gelatin
3) Coagulation of muscle fibres
4) Less hardening

Advantages of Boiling

1) Palatability and digestibility especially in meats
2) Ease of cooking
3) Usage of less fuel
4) Production of nutritious food
5) Sealing the micronutrients
6) Locks volatile flavors
7) Colour and nutrition retention of green leafy vegetables
8) No much physical damage in terms of shape
9) Temperature can be controlled
10) Minimum time requirement

Instructions for Boiling:

1) Sufficient liquid should be added while boiling
2) Pan size should be large to facilitate boiling
3) Simmering to avoid burning

4) Select containers based on amount of food
5) Take care while handling hot liquids
6) Temperatures of liquids are controlled properly
7) Liquid spilling should be avoided

Parboiling:

In this, the food is partially cooked. Food is boiled in liquid for a short time to soften the outer part of the food. Large scale processing is feasible through this method especially in rice.

3.3.2 Blanching:

It might not be a method of cooking. But, it includes placing food in boiling water for less than a minute and then immediately immersing it in cold water.

Advantages of Blanching:

- ➢ Enzymes like polyphenol phosphates can be inactivated
- ➢ Acts like pretreatment for freezing process
- ➢ Seals the nutrition
- ➢ Applicable to vegetables and fruits only
- ➢ Fruits and vegetables peels can be easily removed

Disadvantages of Blanching:

- ➢ Volatile Flavours of foods may leached into cooking liquid
- ➢ Loss of water soluble nutrients is seen
- ➢ Loss of Vitamins is seen

3.3.3 Poaching:

Cooking of food in liquid just below the boiling point is known as poaching. Amount of water is very less compared to boiling

Advantages:

- ➢ Pleasant sensory attributes
- ➢ Improves texture of products
- ➢ Nutrient loss is less
- ➢ Digestibility factor is more

Methods of Poaching:

Poaching is of two types

1. Shallow Poaching
2. Deep Poaching

Shallow Poaching:

- Food is covered in minimum cooking liquid
- Temperatures are below boiling point of water
- Moderately hot ovens are used
- This process prevents boiling
- Controlled cooking is seen

Deep Poaching:

- Food is covered with more water
- Temperatures are near to boiling water
- 8 to 3cms water is used for covering foods
- Makes raw texture of foods edible
- Tenderizes fibrous structure of food

Examples:

- Eggs
- Fish
- Asparagus

Process of Poaching:

- Firstly liquid is heated below boiling point
- Secondly temperature is decreased
- Immersion of food in liquid is seen
- Complete cooking of food is seen
- Liquid can be stored and re processed
- Sauces and vegetable broths are made in this process

Figure: 3.3.3 Process of Poaching

Figure: 3.3.3.1 Separation of Egg Contents by Cracking and Placing in Water

Figure 3.3.3.2 Checking the Doneness of Poached Eggs

Figure 3.3.3.3 Poached eggs dressing with vegetables

(Reference: Vegetables.Co.Nz)

Principles of Poaching:

- ➢ Liquid is maintained below boiling point
- ➢ Proper quantity of liquid is used
- ➢ Damage to food is minimized
- ➢ Uneven cooking can be avoided

Advantages of Poaching:

- ➢ Breakage of texture of food is minimum
- ➢ Easy to digest

- ➢ Usage of fat can be reduced
- ➢ Termed as good food with less fat
- ➢ Can be included in fat less diets

Disadvantages of Poaching:

- ➢ Large chunks of foods can be poached
- ➢ Colour change is minimum
- ➢ Flavour change is minimum
- ➢ Cooking liquid can be retained
- ➢ Nutrients gets leached into cooking liquid

3.3.4 Steaming:

At higher varying pressures, foods are processed by moist heat, especially steam. This process is known as steaming

Purpose of Steaming:

- ➢ Retains vitamins and minerals
- ➢ Edible soft texture is obtained
- ➢ Tasty food can be obtained
- ➢ Easily digestible
- ➢ Micro nutrients can be preserved
- ➢ Low calorie foods can be obtained
- ➢ Ease of processing
- ➢ Economical Processing method

Methods of Steaming:

Steaming is of two types. They are given below:

1) Low Pressure steaming
2) High Pressure steaming

Low Pressure steaming

This method is also known as atmospheric steaming

1) Direct Steaming
2) Indirect Steaming

1) Direct Steaming:

Steamer is used to cook food in boiling water

2) Indirect Steaming:

Plates are used to conduct heat in this process

High Pressure Steaming:

Here steam is trapped inside the system, where steam exerts pressure and further cooking time is reduced.

3.3.5 Vacuum Cooking In Pouch:

- ➢ Sous-vide process
- ➢ Vacuum pouches are used
- ➢ Steam cooking is seen
- ➢ Foods packed in vacuum pouches
- ➢ Economical in nature
- ➢ Controlled cooking
- ➢ In Pouch sterilization
- ➢ Products with more shelf life can be obtained
- ➢ Handling requires skill
- ➢ Vaccum and pressures should be measured

Figure 3.3.5 Tools to Seal Chamber Vacuum Pouches

(Reference: JVR Industries.in)

Advantages:

- ➢ Foods natural juices are preserved
- ➢ Cooking in food juices is seen
- ➢ Texture change is not seen
- ➢ Moisture loss is reduced
- ➢ Standards can be maintained

- Minimal manpower is required
- Garnishing prior to vacuum packing is seen
- Skill is required to process products

Steps of Steaming in Vacuum Cooking:

- Size reduction of food is prerequisite
- Steamers are used
- Trays are used in this process
- Food is cut and placed in trays
- Closed steamers controls temperatures
- Root vegetables are only processed
- Coloured green vegetables are not processed
- Colour distortion of fruits and vegetables is seen.

3.3.6 Pressure Cooking:

- Pressure cooking is employed in this process
- Water is boiled to obtain steam and is placed in sealed container of oven
- Pressure varies with boiling point
- Pressure and boiling point is directly proportional to each other
- Less time is required for cooking
- Here pressure is increased inside the containers
- When pressure is increased, boiling point is also increased, and cooking is done

Procedure of Pressure Cooking:

- Water level should be maintained
- Cooking container should be sealed
- Perforated trays should be used
- Vegetables are mostly pressure cooked
- Pressure should be stabilized after cooking
- Pressure controls should be maintained

Advantages:

- Less cooking time
- Less fuel requirement

- Retains nutrients
- Retains colour
- Retains flavour
- Retains freshness

Figure 3.3.6 Industrial cookers

(Reference: Firex Industries)

Disadvantages:

- Slow temperature dissipation
- Pressure cooker is necessary
- Low flavour development
- Texture modification is seen
- Investment is higher compared to other methods

3.3.7 Stewing:

- Cooking food slowly in minimum liquid, where both liquid and food are served as a meal.
- Size reduction is mandatory.
- Simmering temperatures are seen.
- Tight fitted lid is used
- Time of cooking is increased

Types of Stews:

- White Stew
- Brown Stew

- Vegetable Stew
- Fish Stew
- Blanquette
- Fricassée
- Ragoût
- Navarin
- Ratatouille
- Bouillabaisse

White Stew:

- White meat and milk are cooked together
- Nutrients in meat are leached to milk
- White stew is obtained by removing stews
- White sauce is obtained by adding certain emulsifiers
- Milk gives white colour to the stew

Brown Stew:

- Meat is fried to give brown colour
- Flavour is enhanced
- Red wine is used to improve colour and flavour
- Development of colour and flavour is seen
- Rich dark lamb stew is obtained
- Red wine can be used as cooking liquid

Vegetable Stews:

Simmering is done with following ingredients

- Tomatoes
- Onion
- Eggplant
- Capsicum
- Zucchini

Stew of fish, mussels etc. simmered with herbs are also seen

Advantages of Stewing:

- Retaining flavours is seen
- Nutrients are preserved
- Both solids and liquids are served as food
- Little loss of nutrients
- Simmering point is obtained
- Loss of vitamins is less
- Minerals are mostly preserved
- Tender meats can be obtained
- Older cuts can be made juicy and chewable
- Tough cuts are tenderized
- Bulk cooking can be obtained
- Labour intensive process
- Economical in nature

Principles of Stewing:

- Meats and vegetables are mostly used
- Even cooking is seen
- Bite size pieces are cut
- Frying is one of the process
- Development of flavours and colours is seen
- Sauce of good quality is obtained
- Blanching is seen occasionally
- White meats with less impurities is seen
- Tasty sauces can be obtained
- Longer time cooking
- Slow cooking is preferred
- Tough cuts of meat are tenderized.

Disadvantages of Stewing:

- Longer time cooking
- High rate of evaporation

- Tough protein fibres is seen
- Slow method
- Process should be correctly followed
- Over cooking may lead to mushy meats
- Loss of volatile flavours may be seen

3.3.8 Braising:

Cooking in an oven in liquid in covered pans is known as braising. Its combination method includes stewing and pot roasting.

Purpose of Braising:

- Variety taste
- Exciting menu
- Good Diet
- Tender meat cuts
- Palatability is increased
- Easily digestible
- Safe and nutritious
- Enhances flavour
- Improves texture
- Higher quality can be obtained
- Eating quality has increased.

Figure 3.3.8 Industrial Braising Pans

(Reference: Firex Industries)

Methods of Braising:

1) Brown Braising
2) White Braising

Brown Braising:

Marination, larding and sealing are the key processes. Browning to all sides is seen in the oven. Sealing retains Nutrients. Bed of root vegetables is placed with liquid. Covering with a lid and slow cooking is preferred.

White Braising:

Sweet breads and vegetables are blanched and cooked in white stock and placed in the oven.

Advantages of Braising

- ➢ Tough meats are cooked
- ➢ Expensive meats are cooked proper
- ➢ Nutrients retention is seen
- ➢ Variety of food is seen in menu

3.4 NUTRIENT LOSSES DURING COOKING:

Moist heat methods are the most beneficial methods that retain maximum nutrients. Moist cooking is preferred over dry cooking. Amino acid loss is less when compared to dry cooking. Water soluble vitamins and minerals are leached into the boiling liquids. Some processes discard boiling water and some preserve it. In certain processes, both solid and liquid are used as food**.**

Nutrients may be lost intentionally, inevitably and accidentally. Intentional losses are seen in cereals, inevitable losses are due to blanching, cooking. Accidental losses may be due to storage failures. Vitamin A maximum is preserved. Vitamin B is water soluble and is preserved when boiled waters are retained. Usage of more baking soda removes vitamin B. Vitamin C loss is little compared to others.Protein coagulation is less. More peeling removes vitamins beneath the skin. Edible leaves remove vital nutrients. Sodium, Potassium and chlorine are removed by discarding cooking water. Oxidation removes Vitamin C.

3.5 SUMMARY:

Inclusion of moisture during cooking is preferably good if shelf life is not a factor. Special care must be taken when dealing with moisture, as it may enhance water activity. Loss of nutrients is very less and these methods are preferred when healthy diets are processed. As little or no fat is used, taste may be compromised. Economically these methods are feasible and bulk cooking is possible with these processes. Many vegetables are processed with these methods with maximum retention of carotenoids and flavonoids.

3.6 TECHNICAL TERMS:

Moist heat methods, Braising, Boiling, Pressure cooking, Poaching, Nutrient retention.

3.7 SELF ASSESSMENT QUESTIONS:

1) What are moist heat methods?
2) Discuss about boiling and poaching.
3) Explain poaching and braising.
4) Give advantages and disadvantages of moist heat methods.
5) Compare boiling and stewing.
6) Give examples of poaching and braising.

3.8 REFERENCE BOOKS:

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LESSON-4

MICROWAVE AND SOLAR COOKING METHODS

OBJECTIVES:

After studying this lesson, you should be able to:

- To know about Microwave and solar methods of cooking.
- To study about advantages and disadvantages of methods of cooking.
- To study about nutrient losses during cooking.

STRUCTURE:

4.1 INTRODUCTION:

Microwave cooking and solar cooking are the modern ways of cooking. Microwave refers to cooking in a microwave oven. It is different from dry heat and moist heat methods. It majorly refers to a secondary processing method. It is used for processing or heating prepared foods and for thawing raw meats. For foods like baked goods, it serves as the primary cooking method. It uses power from 500 Watts to 2000 watts. More energy gives faster cooking times.

Solar cooking is quite different from microwave cooking as it involves natural sunlight. In the areas of abundance sunlight, solar ovens and solar cookers are used. This method of cooking utilizes renewable sources of energy and is pollution free. Rather than cooking food, it is used to pasteurize water, vegetable and fruit dried bites and utensil sterilization. The major hindrance of this method is climate changes. At night time, these cookers don't work. Proper precautions should be taken, so that foods will not get spoiled or contaminated due to climate or temperature fluctuations.

4.2 MICROWAVE METHODS OF COOKING:

Microwave cooking need not have any medium for transfer of heat. The power source called magnetron is seen which constantly emits electromagnetic waves. The electromagnetic waves are absorbed by food and food heats its surface at once Microwaves play a major role in cooking. Two phenomena are observed which are absorbance, transmittance or reflectance. Reflection of heat by metals is seen which further cooks foods. Magnetron emits electromagnetic waves that strike the food and metal walls of the oven.

The microwaves that hit the walls of the oven reflect and bounce back. The waves that bounce back are dispersed throughout the oven. This dispersion of electromagnetic waves are the reasons for uniform heating of foods. The speciality of microwave cooking is that heat is generated from the inside portions of foods. The energy emitted by microwaves is absorbed by water molecules and they get excited as they have dipole nature. The excited water molecules in foods vibrate 2450 million times a second.

The vibration of water molecules causes friction which in turn creates heat. This heat enables microwaves to penetrate into the food components easily. Composition of food and formulation is one of the key factors for proper microwave cooking. Different ingredients in food react differently at different rates based on their composition. Foods contain more than 70% of water and it has greater efficiency to convert microwave energy to heat energy. Starch cellulose and proteins have medium efficiency to convert the energy, where fatty acids have the least capacities. The major difference in conversion capacities is due to variance in moistures.

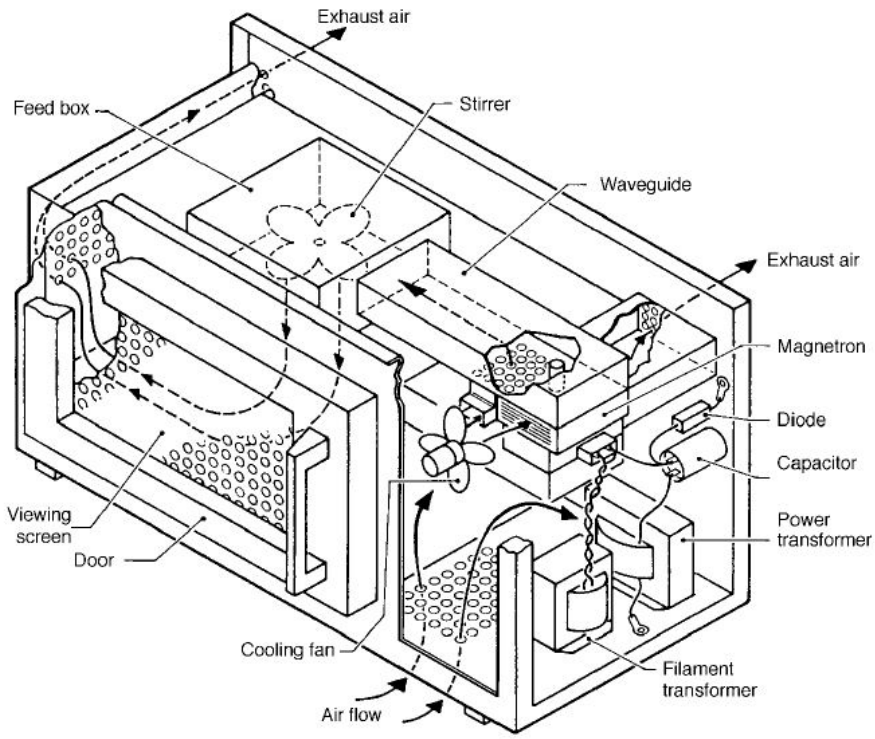


Figure 4.2.1 Microwave oven with magnetron

(Reference: CR Buffler, 1993)

Figure 4.2.2: Halogen Filling Space inside Microwave Oven

(Reference: Reference Module in Food Science, 2016)

Figure 4.2.3: Pumping of hot air jet in oven

(Reference: Reference Module in Food Science, 2016)

Figure 4.2.4: Hot air and grills

(Reference: Reference Module in Food Science, 2016)

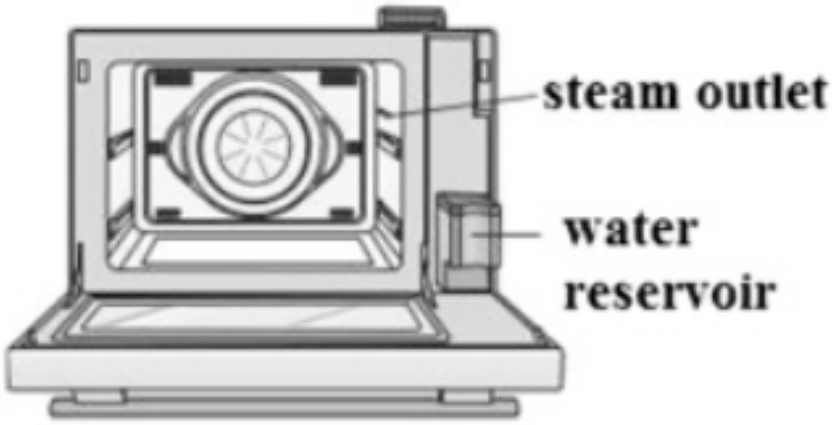


Figure 4.2.5: Water reservoir and steam outlet in microwave oven

(Reference: Reference Module in Food Science, 2016)

Microwave safe materials are used for cooking foods as they don't absorb waves and are given below.

1) Paper Dishes
2) Plastics
3) Glass
4) China ware
5) Ceramics
6) Aluminium Foils

The following materials should be avoided to prevent mishaps during food processing.

1) Brown paper bags
2) Stainless steel
3) Metal twist ties
4) Conventional thermometers

Materials prescribed for microwave ovens are only used as they dont react with microwaves. Microwave safe materials are easier to wash and paper dishes can be thrown away. Water is not used for cleaning the oven, but wiped with dry, clean damp cloth. Microwave cooking preserves flavour and colour of foods. Enhancement of flavour is also seen. Reheating of food also can be done. The below pre cooked processed foods are processed more using microwave cooking

1) Tikkas
2) Kababs
3) Dals

4) Chicken gravies
5) Toasted nuts
6) Poaching eggs
7) Idlis
8) Popcorn
9) Reheating chapatis
10) Oil free papads
11) Vadams

The difference between microwave and conventional cooking is done by time rather than temperature.

4.2.1 INSTRUCTIONS FOR USING MICROWAVE OVEN:

- Microwave cannot be used for home canning and for any closed jar cooking
- Pressure buildup is seen in closed jars, which lead to explosion
- Dont heat the liquids without stirring
- Whole foods should be pierced while keeping in oven
- Do not dry meat, herbs, vegetables in oven
- Don't use hot oils in ovens
- Deep fat frying should be avoided while dealing with microwave ovens
- Dont heat eggs with shell, which leads to explosion
- Overcooking of vegetables should be avoided
- Dont use synthetic fibres to ignite towels
- Don't use recycled paper products in oven
- Don't leave oven open and unattended
- Do not use narrow mouthed containers to avoid spillage
- Bones should not be placed in oven
- Wrapper should be perforated so that steam escapes from the system
- Oven gloves should be used to avoid steam burning
- Tender meats should be cooked in liquids
- Minimum cooking time should be maintained for cooking
- Browning of food is seen for large cuts. Foods that don't require browning should be reduced in size

- Overcooking should be avoided as it cannot be undone
- For even cooking, rotation of plates is necessary
- Thaw foods using defrost cycles. Less power enables even thawing
- Always dry foods should be covered with plastic or wax paper to avoid texture changes.

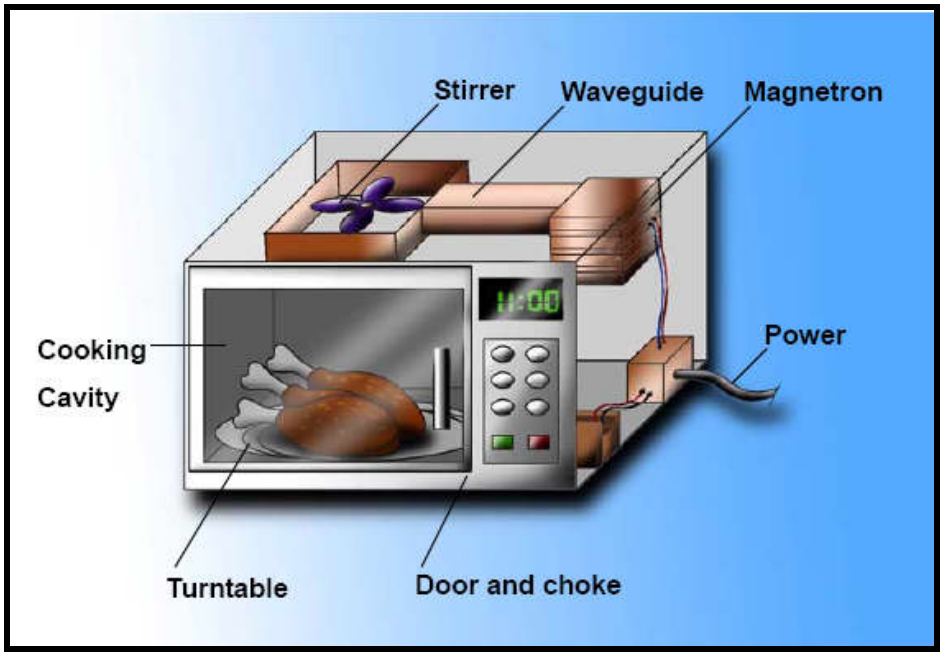


Figure 4.2: The microwave oven and its parts

(Source: Food Science by B Srilakshmi, seventh edition)

4.2.2 ADVANTAGES OF MICROWAVE COOKING:

- Less energy is required for operating microwave ovens
- Thawing and cooking can be done in minutes or seconds
- The vessels are not heated, only food is heated
- Reheating the food will not change the flavour and texture of foods
- Minimal loss of nutrients is seen
- Beta carotene and Vitamin C are retained in microwave cooking
- Washing microwave oven dishes is easy compared to other methods
- Uniform cooking of food is seen
- Preservation of natural colour of foods is seen
- Low fat cooking is possible without burning
- Fat free foods can be obtained

4.2.3 DISADVANTAGES OF MICROWAVE COOKING:

- ➢ Desirable browning is not seen except the oven has a browning unit
- ➢ Microwave cooking cannot cook soft or hard boiled eggs
- ➢ Deep frying is not recommendable
- ➢ Microwave safe vessels only should be used
- ➢ Flavour blending is not seen like conventional methods
- ➢ Longer exposure to microwave cooking leads to physiological abnormalities
- ➢ Foods should be thicker enough with good moisture content to facilitate microwave penetration

4.3 SOLAR METHODS OF COOKING:

Definition: Solar cookers use sunlight where it is converted to heat energy and is also retained during cooking. Cooking by the means of natural sunlight is generally termed as solar cooking.

Steps for solar cooking

1. Concentration of sunlight
2. Conversion of light to heat
3. Trapping of heat

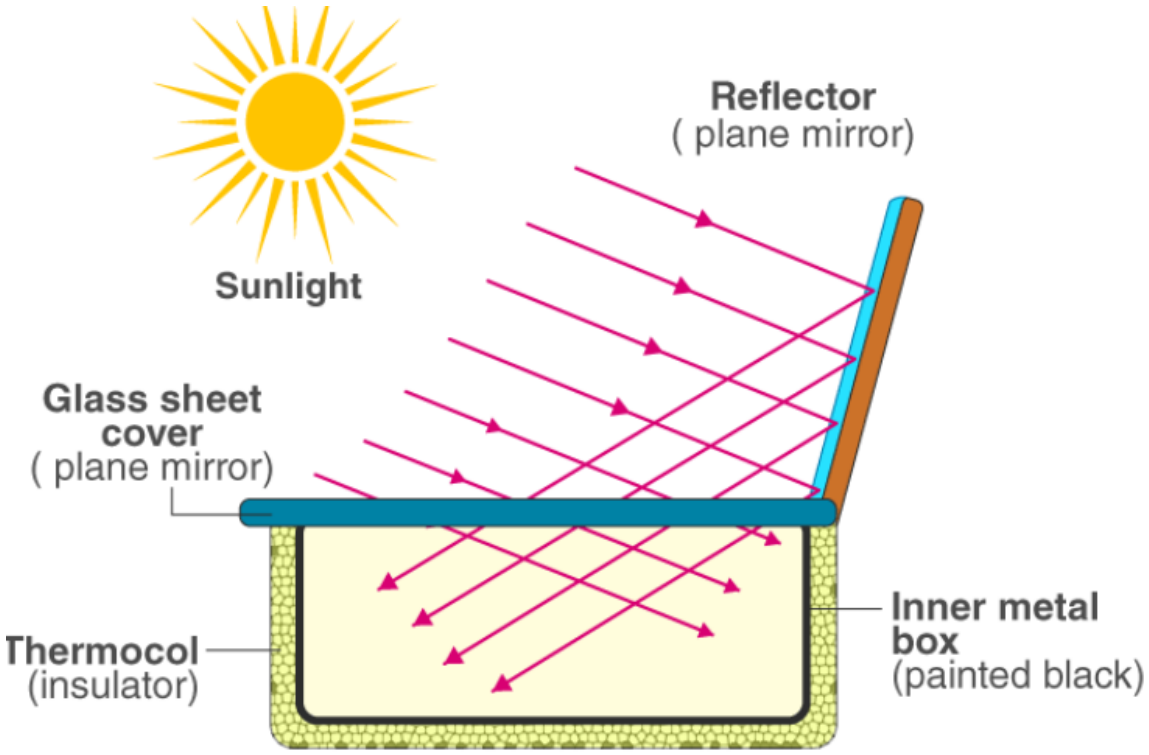


Figure 4.3: Solar cooking Process

Concentration of Sunlight:

A mirror or reflective metal is used to reflect sunlight. The light is reflected to the central point and is concentrated. This is very stronger form of energy

Conversion of Light to Heat:

Black pots or pans are used to absorb and retain heat energy. Generally black cookers are used.

Trapping of Heat:

Greenhouse effect is created to ensure trapping of steam. Isolation of the cooker from inside is very important to ensure heat retainment.

Solar cooking is one of the sustainable cooking alternatives which retains nutrients in foods. Operating costs are very low and are environmentally friendly. This method is adopted in residential schools, institutional kitchens, canteens, ashrams, hospitals, and armed force kitchens. Solar cookers save 35 to 45 LPG cylinders per year in community kitchens.

Solar cooking implies the following methods of cooking.

1) Boiling
2) Frying
3) Roasting
4) Baking

4.3.1 SOLAR COOKERS:

These are characterized by reflective surfaces that focus mainly on solar energy on pot to give higher temperatures. Surface tracks the sun on a continuous basis. This uses direct sunlight effectively. It is fitted with a disk, and it reflects light to the focal point.

Solar cookers are the cookers which facilitate solar cooking in foods.Most of the types cook food on an open fire or electric stove. Stews and bread can be processed by these cookers. Little attention is required while cooking. Burnings may not happen as there is control of temperatures. No harmful gases are released. Even cooks food in Indirect sunlight. Temperatures near to 115ºC are obtained. But these cannot be used on cloudy days and cooking time is more, when compared to other methods. Solar cookers are categorized into 4 types based on construction. They are given below

1) Box cookers (~100 °C)
2) Concentrating Cookers (>100 °C) (e.g., Parabolic dish)
3) Round the clock cookers (RTC) (>100 °C)
4) Community Cookers (superheated steam-based). Community-based solar cookers are used in famous temples across India.

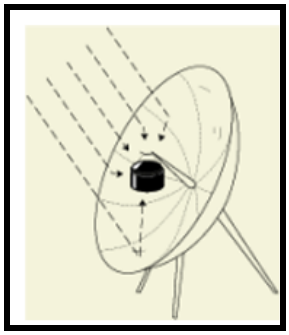


Figure 4.3.1: Solar Cookers

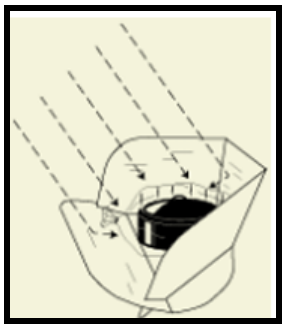


Figure 4.3.2: Solar Oven

4.3.2 SOLAR OVENS:

These cookers contain boxes with insulating materials and various heat trapping enclosures. The box is fitted with a transparent medium such as plastic or glass. This construction helps the cookers to use incident solar radiation to cook food inside. Insulating materials keeps temperatures hot inside even on cool days. Heat blockages and seepages can be avoided by using protective measures like this. Dark coloured cooking pot is recommended as it absorbs more heat. Preheating the sun stove by placing brick inside to heat up and to retain heat.

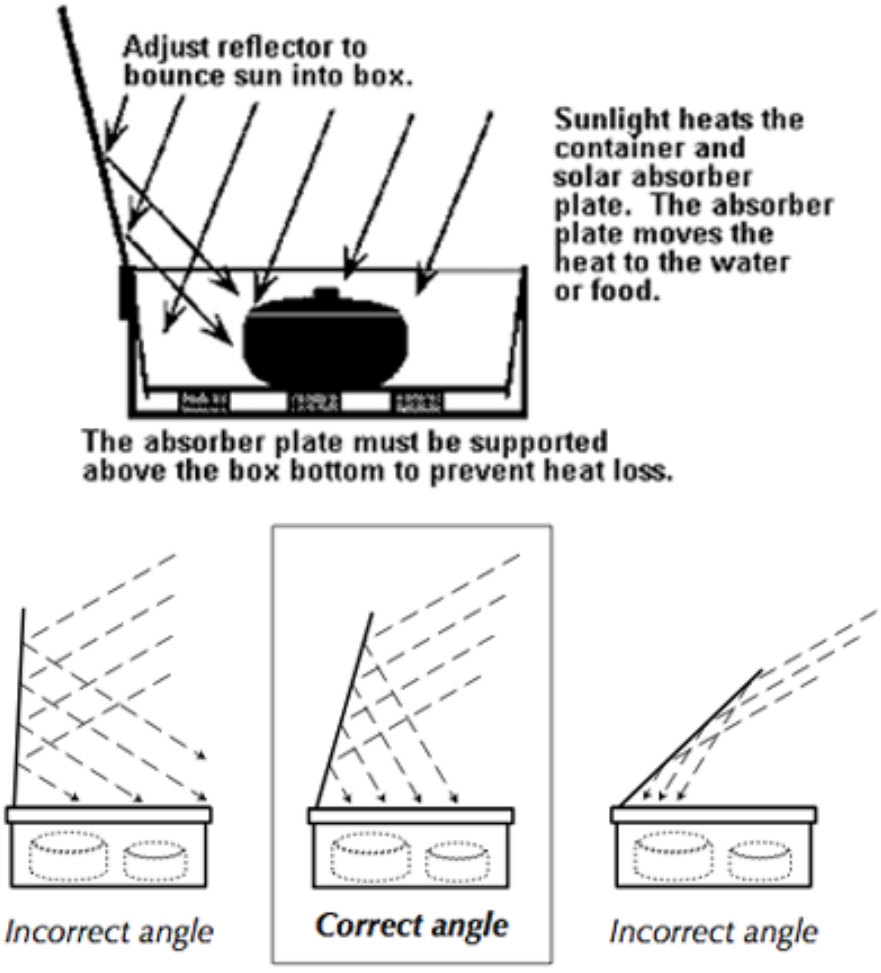


Figure 4.3.3: Operation of solar oven

Figure 4.3.4: Example of solar ovens

4.4 ADVANTAGES OF SOLAR COOKING:

- ➢ No fuel is required to operate solar cookers
- ➢ Cost saving method and is economical
- ➢ Operational feasibility is more
- ➢ This method implies no pollution
- ➢ Carbon dioxide based fuels are not used
- ➢ No fire accidents are seen
- ➢ No much attention is required to operate solar cookers and ovens

4.5 DISADVANTAGES OF SOLAR COOKING:

- ➢ Cloudy weathers will not support solar cookers
- ➢ Time Consumption is more compared to other conventional methods
- ➢ Larger cuts may not be cooked efficiently
- ➢ Slower cooking is seen when compared to other methods

4.6 NUTRIENT LOSSES DURING COOKING:

Microwave cooking retains almost all nutrients since cooking time is very less. When compared to other methods of cooking, where more moisture is used, microwave cooking better safeguards food components in terms of nutrition. Some antioxidants may be preserved in microwave cooking. Example is glucosinolate in broccoli. Little liquid is used for cooking and steaming is done inside out. Hence we can say that most of the minerals and vitamins are preserved by using this cooking method and are healthy in nature. Solar cooking is always the best choice for destroying microbes but vitamin C is detrimental in nature. Conventional methods of cooking retain more vitamin C. For maintaining overall quality of food, combination methods may be used.

4.7 SUMMARY:

Foods are made of nutrients which fulfills the functioning aspects of the body. In all the components, vitamins and minerals are most important and are termed as micronutrients. Even though required in small amounts, these are essential to run the body for longer times. These are found mostly in fruits and vegetables. Cooking of food using less heat or cooking for less time may retain nutrients upto some extent. Both microwave and solar cooking affects the nutritional quality and microbial population. But when compared with microwave cooking, solar cooked foods showed less microbial load. Maximum vitamin C is retained in microwave cooking.

4.8 TECHNICAL TERMS:

Microwave cooking, solar oven, Solar cooking, Nutrients, Nutrient retention.

4.9 SELF ASSESSMENT QUESTIONS:

1) Describe Microwave.
2) Give a neat diagram of the microwave oven.
3) Explain solar cooking methods
4) What are different types of solar cookers?
5) Write about solar cooking.
6) Write about nutrient losses in microwave and solar cooking.
7) Write about advantages and disadvantages of microwave cooking.
8) Write about advantages and disadvantages of solar cooking.

4.10 REFERENCE BOOKS:

1) C. R. Buffler, “Microwave Cooking and Processing: Engineering Fundamentals for the Food Scientist,” Van Nostrand Reinhold, New York, 1993.
2) Website - Ministry of New and Renewable Energies, Government of India.
3) Effect of conventional, microwave and solar processing on vitamin C content and bacterial load of some foods, N.R. DAVE AND B.M. VAID Asian Journal of Home Science (June, 2010) Vol. 5 No. 1 : 193-196. Revised : February, 2010; Accepted : May, 2010
4) Search Engine-Google Learning Apps.
5) Microwave Processing of Frozen and Packaged Food Materials: Experimental, Lineesh Punathil, Tanmay Basak, in Reference Module in Food Science, 2016.

Dr. B. Babitha

LESSON-5

CEREALS AND MILLETS

OBJECTIVES:

After going through this lesson students will understand:

- Classification and composition of vegetables and fruits
- Pigments and flavour constituents
- Effect of cooking
- Browning reactions

STRUCTURE:

5.1 INTRODUCTION:

CEREALS:

The cereal grains are seeds of the grass family. The word cereals are derived from ceres, the roman goddess of grain. The principal cereal crops are rice, wheat, maize, corn, jowar, ragi, bajra. The germ cereal is not limited to this but as flour, meals, breads and alimentary paste and pasta.

Cereals supply the bulk of the food consumed by the human race. They are the cheapest source of food energy and constitute a high percentage of the calorie and protein intake of man, particularly in the developing countries. Cereals have been grown from primitive times. During the long period of the cultivation of cereal crops, new species and varieties have been evolved, to suit the cultural conditions of the different parts of the world. Cereals are also used as animal feed and for industrial purpose.

MILLETS:

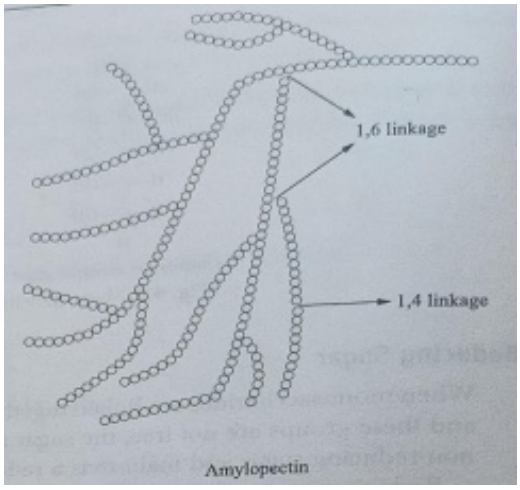
These are hardy plants capable of growing in areas where there is low rainfall and poor irrigation facilities. Apart from maize and sorghum, the major millet crops of India are pearl millet called bajra, Italian millet known as foxtail millet, little millet known as samai, varagu is known as kodo millet and finger millet known as ragi.

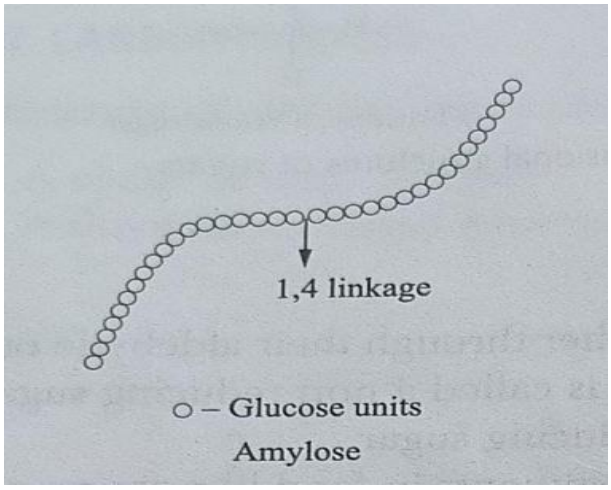
5.2 STARCH STRUCTURE:

STARCH:

Starches contain only glucose residues. They are mixtures of the structurally 'distinct polysaccharides, amylose and amylopectin. Cereal starches usually contain 25 per cent amylose and 75 per cent amylopectin. Waxy or glutinous starches like waxy corn starch contain little or no amylose. Waxy varieties of corn and sorghum starches have found use in food-pie fillings and puddings. Amylose has great industrial possibilities and hence, by breeding, corn with starch of high amylose content (about 85 per cent), has been obtained. In addition to these components, starch granules commonly contain small amounts of proteins, fatty substances and inorganic material. The non-carbohydrate constituents are of relatively little importance in relation to food use, but they affect the physical properties of starch.

STARCH STRUCTURE:





Starch is found in most parts of a plant as a reserve store of carbohydrates. It is usually present in the seed and root in large amounts. Cereals contain approximately 70%, pulses 60%, and potatoes 22% starch.

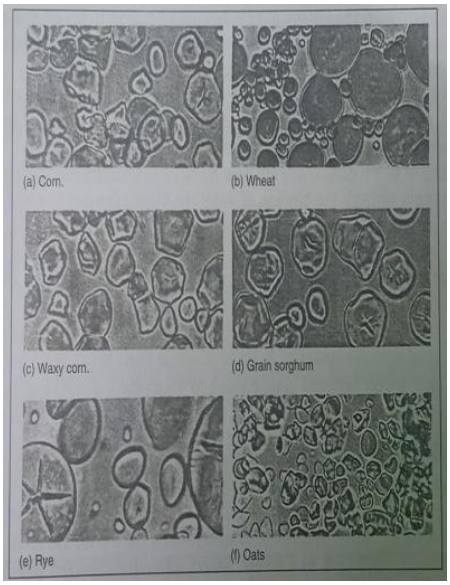
Starch consists of long chains of glucose units present in two forms Amylose and Amylopectin.

Amylose: Amylose is a large molecule made up of 200 or more glucose units linked by 1,4-<-glucoside linkages. They are present as linear chains which can bond to each other by hydrogen bonds and form a gel. The glucose units in Amylose are linked each other by eliminating water molecule at each linkage.

Amylopectin: Two types of linkages are seen in Amylopectin 1,4-<-glucosides linkages and 1,6-<- glucoside linkages resulting in a branches polysaccharide. The 1,4 linkages form a straight chain of 15-30 glucose units after which 1,6 linkages occur resulting in cross linking. The molecules Amylopectin is very large, because of its branches structure doesn't form gel.

5.3 CHARACTERISTICS OF SOME FOOD STARCHES:

Starch granules are densely packed with Amylose and Amylopectin. each type of starch has a characteristic shape by which it can be microscopically identified. The size varies from a few microns to 100 microns.
Tapioca, the root starch from cassava, has small round or oval granules.
Sago, starch granules are elliptical in shape.
Potato, starch granules are large and shapes like mussel shells.
Corn, starch granules are polygonal in shape.
Wheat, starch has two types of granules small spherical granules and large disk-shaped granules.
Rice, starch granules are polygonal in shape but, very small in size.



Source: Ungelatinized Starch Granules (Magnified 500times)

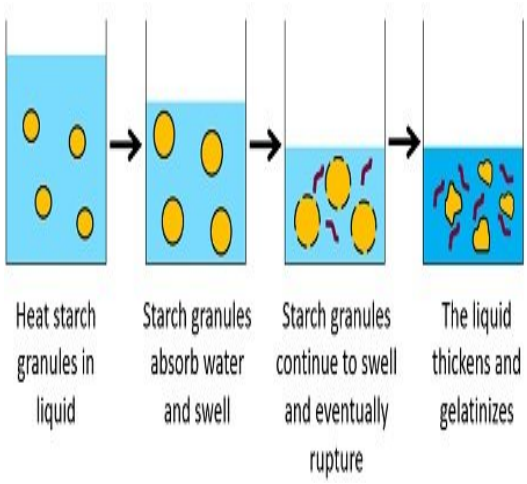
5.4 GELATINIZATION:

Starch granules do not dissolve readily in cold water but they will form a temporary suspension with the starch tending to settle out as soon as the mixture is allowed to stand. When heated with water, the intra-molecular hydrogen bonding is broken and grains absorb water and (a) swell, (b) the viscosity increases until a peak thickness is reached and (C) the translucency of the mixture also increases. The term gelatinization is used in general to describe these changes. The changes appear to be gradual over a temperature range during gelatinization. The change transforms the temporary suspension into a more permanent one. The swelling of starch particularly amylase resulting in the formation of a gel with water is believed to occur through the binding of water.

In starch, the amylase and amylopectin molecules are loosely bound together by hydrogen bonds of the hydroxyls. The hydrogen on the hydroxyl on one molecule is attracted by the negative charge of the oxygen of a hydroxyl on other molecule and this attraction forms a weak link between the molecules. As the temperature increases of the starch water mixture, the hydrogen bonding decreases for both the starch-starch bonds and water-water bonds and the size of the particles diminishes. Increasing water molecules begin to penetrate freely between the starch molecules when their kinetic energy becomes great enough to overcome the attraction between starch molecules. Two starch molecules which were originally bound together are now two starch molecules with water in between. The sticking together of granules is the result of molecules from adjacent granules becoming attracted and enmeshed in one and other. The changes brought about by hot water on starch are irreversible.

Gelatinization is the process of breaking down the bonds between starch molecules and causing the starch granules to swell and absorb liquid, resulting in a thick consistency. Starch gelatinization is a physical process that occurs when starch granules are heated in water, causing them to swell, break, and dissolve in the water Starch granules are made up of amylose and amylopectin, and when heated in water, the intermolecular bonds of the starch molecules break down. This allows the hydrogen bonding sites to engage with more water, causing the granules to swell and burst.

STEPS IN GELATINIZATION:



Gelatinization is the first step in the modification of starch using the precipitation method. It's also a process that occurs during mashing in brewing, where hot water dissolves the starch and allows enzymes to break the starch molecules into sugars.

Initial Water Absorption: Water molecules enter the starch granules when heated

Swelling: The granules swell as they absorb more water.

Loss of Crystallinity: The ordered structure of the starch granules is disrupted, causing them to burst.

Gelation: The contents of the starch granules disperse and interact, forming a viscous paste.

5.5 FACTORS AFFECTING GELATINIZATION:

Temperature and time of heating: Starch pastes may be prepared most quickly by bringing them to a boiling temperature over direct heat, constantly stirring as they thicken and simmering them for approximately one minute. Under carefully controlled conditions, starch pastes that are heated rapidly are somewhat thicker than similar pastes heated slowly. **Proportions of starch**: More concentrated dispersions of starch show higher viscosity at lower temperatures than do less concentrated mixtures because of the larger number of granules that can swell in the early stages of gelatinization. Each type of starch gelatinizes over a characteristic temperature range; although this range may be affected by starch concentration.

Types of starches: The starches vary in their thickening power. Wheat starches gelatinize earlier compared to rice, sorghum or corn starch. Corn or sorghum starch give opaque pastes of higher viscosity than wheat starch at the same concentration. Waxy corn starch (more amylopectin) does not form a gel and remains clear because of lack of amylase. Flour that has been browned has less thickening power as some of the starch molecules had been converted to dextrin's.

Agitation or stirring: Stirring while cooking a starch mixture is desirable in the early stages for obtaining uniform consistency. However, if agitation is too intense or continued too long it accelerates the breakdown or rupturing of the starch and decreases viscosity and may give a pasty mouth feel.

Addition of other ingredients: Sugar: The sugar added decreases the thickness of the cooked product. Sugar limits the swelling of starch grains while competing with them for water. In addition, it elevates the temperature at which starch grain begins to thicken a liquid. It also makes the swollen grains more resistant to mechanical rupture after they are gelatinized. In a recipe calling for a large amount of sugar, only part of the sugar needs to be added before cooking. After the starch mixture has been cooked, the remainder of the sugar can be added with much less effect on viscosity.

Acid: Acid in the form of vinegar or time juice reduces the thickness of hot starch paste and the firmness of the cooled paste. The decrease in thickness and stiffness has been attributed in part to fragmentation of swollen granules and hydrolysis of starch molecules. Acid and heat catalyse the hydrolysis of starch to dextrin's. Acid hydrolysed starch, when it is boiled hydrates at lower temperature than the unmodified starch. Acid thinned starch is often used in confectionery industry.

In cooked starch mixtures like custards containing fruits soma amount of thinning occurs. When a high concentration of sugar is also present in a starch paste, the sugar may help to decrease the effect of acid, because sugar limits the swelling of starch granules and starch molecules are therefore not as available for hydrolysis of acid. Acid juices such as lemon juice can also be added after the starchy paste has been cooked. This limits the acid's contact with starch molecules.

Fats and Proteins: The presence of fats and proteins which tend to coat starch granules and thereby delay hydration also lower the rate of viscosity development.

5.6 MODIFIED FOOD STARCHES AND THEIR APPLICATIONS:

Gel Formation: The starch released into the liquid causes it to thicken. Gelatinization is complete when the liquid reaches around 96°C. As the mixture cools it thickens even more, setting and firming. It turns into a gel at about 38°C.

Retogradation: Starch retrogradation is a process that occurs when starch-based foods are exposed to moisture or freeze-thaw cycles, causing the starch chains to reassociate and form more ordered structures. This process can have both desirable and undesirable effects on the food

Syneresis: Starch syneresis is the process by which water separates from starch gels after storage. It can be measured by subtracting the weight of the separated water from the weight before the cycle.

Applications:

1) **Food Industry:**

   Thickening Agent: Used in soups, sauces, gravies, and puddings to improve texture.

   Baking: Enhances the structure of bread, cakes, and pastries by improving water retention and texture.

   Confectionery: Provides the desired texture in candies, jellies, and gums.

   Dairy Products: Helps in the production of custards, yogurts, and other creamy products.

2) **Beverage Industry:** Improves viscosity in drinks like instant coffee or chocolate milk. Stabilizes emulsions in beverages like fruit juices and flavoured milk.
3) **Pharmaceuticals:** Used in capsules and tablets as a binding and disintegrating agent. Stabilizes emulsions and suspensions in syrups.
4) **Textile Industry:** Acts as a sizing agent in textiles to strengthen yarns and fabrics during weaving**.**
5) **Paper Industry:** Improves paper strength and surface finish by acting as a binder.
6) **Cosmetics:** Used in lotions, creams, and masks to provide a gel-like texture and improve stability.
7) **Adhesives:** Utilized in starch-based glues for packaging and bookbinding due to its gel-forming properties**.**
8) **Bioplastics:** Plays a role in developing biodegradable films and packaging materials.
9) **Animal Feed:** Enhances digestibility in pet foods and livestock feed.
10) **Scientific Applications:** Gelatinization is used in research to study the behaviour of starches under different condition.

5.7 PECTIN AND GUMS: FUNCTIONAL ROLES IN FOOD PRODUCTS:

PECTIN: Pectin is a naturally occurring polysaccharide (complex carbohydrate) that is predominantly found in the cell walls of plants. It is especially abundant in fruits, where it helps to bind the plant cells together. Pectin is made up of a backbone of galacturonic acid (a sugar acid) units, linked together by glycosidic bonds. The structure also contains various sugar molecules like rhamnose, arabinose, and galactose. The degree of methylation (the presence of methyl groups) affects its gelling properties.

- **Sources**:

  Citrus fruits (lemons, oranges, grapefruits) are among the richest sources of pectin.

  Apples, particularly their skins and cores, contain high amounts of pectin.

  Other fruits like pears, strawberries, and apricots also contain pectin, but in lower concentrations.

- **Uses**:

  Gelling agent: Pectin is most commonly used in making jams, jellies, and marmalades. When mixed with sugar and acid (like lemon juice), pectin forms a gel-like structure, which is ideal for these products.

  Food and beverage applications: It is also used in fruit-based fillings, gummies, and some beverages to improve texture and consistency.

  Health benefits: Pectin is a type of soluble fibre, which can aid in digestion, improve gut health, and lower cholesterol levels. It is often included in dietary supplements.

  Functional properties: In addition to its gelling ability, pectin helps in stabilizing emulsions and can act as a thickening agent in some processed foods.

FUNCTIONAL ROLE IN FOOD PRODUCTS:

1) Gelling Agent:

- **Primary role:** Pectin is widely used as a gelling agent in the production of jams, jellies, and marmalades. When pectin is combined with sugar and an acid (such as citric acid or lemon juice), it forms a gel structure.
- **Mechanism:** The gelling process occurs due to the interaction of pectin molecules, which form a network that traps water and other ingredients, resulting in a thick, stable gel. This is crucial in creating the firm, spreadable texture found in preserves.
- **Products:** Jams, jellies, fruit preserves, marmalades, and fruit fillings.

2) Thickening Agent:

- **Application:** Pectin can also act as a thickening agent in various food products, providing a desired consistency without the need for excessive amounts of fat or sugar.
- **Mechanism**: It helps increase the viscosity of liquids, making it valuable in products where a thicker consistency is needed, such as sauces, gravies, soups, and some beverages.
- **Products:** Sauces, dressings, soups, smoothies, and fruit beverages.

3) Stabilizer in Emulsions:

- **Role:** Pectin helps stabilize emulsions, which are mixtures of water and oil that do not naturally combine. It prevents separation, ensuring that the emulsion remains homogeneous over time.
- **Mechanism:** Pectin acts as a stabilizer by interacting with both the water and fat components of the emulsion, providing a barrier that reduces the risk of separation.
- **Products:** Mayonnaise, salad dressings, margarine, and cream-based sauces.

4) Water Retention and Moisture Control:

- **Role:** Pectin can help retain moisture in food products, which is particularly important in preventing them from becoming dry or stale. This moisture-retaining property helps improve shelf life.
- **Mechanism:** Due to its high water-binding capacity, pectin helps maintain the moisture content in foods, preventing them from losing texture or becoming too hard.
- **Products**: Baked goods, gummy candies, confectionery, and fruit fillings.

5) Fat Replacer:

- **Application:** In some products, pectin can serve as a fat replacer, providing structure and texture while reducing the fat content.
- **Mechanism:** Pectin can replace part of the fat content in products like low-fat or fat-free jams, jellies, or dairy-based items, helping to maintain creaminess and mouthfeel without adding excess calories.
- **Products**: Low-fat jams, jellies, dairy products, and some processed foods.

6) Prebiotic Dietary Fiber:

- **Health Function:** Pectin is a soluble fibre, which means it has beneficial effects on digestion and gut health. It can help promote growth of beneficial gut bacteria and contribute to digestive health.

- **Mechanism:** When consumed, pectin is fermented in the colon, producing short-chain fatty acids that are beneficial for gut health and may help lower blood cholesterol levels.
- **Products:** Functional foods, dietary supplements, fibre-enriched beverages, and health-focused snack products**.**

7) Clarifying Agent:

- **Role**: Pectin can also function as a clarifying agent in the production of fruit juices and beverages.
- **Mechanism:** It helps remove excess cloudiness by binding with particles that cause turbidity, leading to clearer liquids without affecting flavour or taste.
- **Products:** Fruit juices, cider, and other beverages that require clarification.

8) Controlled Crystallization:

- **Function**: In the production of candies (like fondant) or certain confections, pectin can help control the crystallization of sugar.
- **Mechanism:** It helps create smooth, non-crystalline textures by interfering with the formation of sugar crystals, contributing to the smoothness of candy and confectionery products.
- **Products:** Gummy candies, marshmallows, fondants, and some fruit-based confections.

9) Improved Texture in Gluten-Free Products:

- **Application:** In gluten-free baking, pectin can improve the texture and elasticity of dough or batter that would otherwise lack structure due to the absence of gluten.
- **Mechanism**: Pectin's ability to bind water and form a gel-like network can help replicate the textural properties that gluten normally provides in traditional baked goods.
- **Products**: Gluten-free bread, cakes, cookies, and muffins**.**

10) Colour and Flavour Stabilizer:

- **Role:** Pectin can help stabilize the colour and flavour of fruit-based products, such as fruit fillings or fruit-flavoured beverages.
- **Mechanism:** By preventing the separation of ingredients and maintaining the texture, pectin helps preserve the natural colour and flavour of fruits, preventing degradation during processing or storage.
- **Products**: Fruit fillings, fruit juices, and certain dairy products.

Gums: Gums are a diverse group of polysaccharides that are either extracted from plants or produced through microbial fermentation. They are highly soluble in water and can form viscous solutions or gels depending on their type. Gums consist of complex carbohydrates that vary in their composition, but they typically contain sugar molecules such as glucose, galactose, mannose, and galacturonic acid. They may also have functional groups like sulphate or acetate that affect their properties. Depending on the specific type of gum, the molecules can either be branched or linear, influencing their solubility and thickening capacity.

- **Sources:**
- **Plant-based gums**: These are typically extracted from tree saps, seeds, or the roots of various plants.
    - **Guar gum**: Derived from the seeds of the guar plant, commonly used as a thickening agent in sauces, soups, and baked goods.
    - **Xanthan gum**: Produced through the fermentation of sugars by the bacterium *Xanthomonas campestris*, it is commonly used in gluten-free baking, salad dressings, and to stabilize emulsions.
    - **Acacia (gum Arabic)**: Harvested from the sap of acacia trees, this gum is often used in beverages, confectionery, and as a stabilizer in emulsions.
    - **Locust bean gum (carob gum)**: Extracted from the seeds of the carob tree, used in dairy products, sauces, and ice cream for its thickening and gelling properties.
- **Uses**:
- **Thickening agent**: Gums are widely used in the food industry to increase the viscosity of liquids without altering their flavour, such as in sauces, dressings, gravies, soups, and beverages.
- **Stabilizing emulsions**: Gums help prevent the separation of oil and water in emulsified products like mayonnaise, ice cream, and margarine.
- **Texture enhancement**: In products like ice cream, gums provide creaminess and smooth texture by reducing ice crystal formation during freezing.
- **Gluten-free baking**: Many gums, such as xanthan and guar gum, are essential in gluten-free baking to mimic the structural properties of gluten, helping to provide elasticity and texture to bread, cakes, and cookies.
- **Health applications**: Some gums, like guar gum and xanthan gum, are dietary fibres that can support digestive health and regulate blood sugar levels.

FUNCTIONAL ROLE OF GUMS IN FOOD PRODUCTS:

1) Thickening Agent:

- **Primary Role:** Gums are most commonly used to thicken liquid food products, increasing their viscosity without altering the flavour**.**
- **Mechanism:** Gums dissolve in water and create a thick, gel-like structure by binding to water molecules, which enhances the texture of the product.
- **Products**: Sauces, gravies, soups, salad dressings, beverages, and ice cream.

2) Emulsifying Agent (Stabilization of Emulsions):

- **Role:** Gums help stabilize emulsions, which are mixtures of oil and water (two immiscible liquids).
- **Mechanism:** Gums act as emulsifiers, preventing the separation of oil and water by forming a protective layer around oil droplets, which keeps the emulsion uniform.
- **Products:** Mayonnaise, salad dressings, ice cream, margarine, and cream-based sauces.

3) Water Retention and Moisture Control:

- **Role**: Gums are excellent at water retention, which helps control moisture content in foods, improving texture and shelf life.
- **Mechanism:** Gums bind water molecules, preventing dehydration and helping to retain moisture in products, thereby preventing them from becoming dry or stale.
- **Products:** Baked goods (bread, cakes, and pastries), processed meats, fruit fillings, and confectionery.

4) Texturizing Agent:

- **Role:** Gums contribute to the texture of food products, helping to create desired mouthfeel and consistency.
- **Mechanism:** By binding with water and forming gel-like structures, gums can provide smoothness, creaminess, or a chewy texture in various foods.
- **Products**: Ice cream, puddings, custards, candy (e.g., gummies), and processed cheese.

5) Fat Replacement:

- **Role:** Gums are sometimes used as fat replacers in low-fat or fat-free products.
- **Mechanism**: Gums help maintain the creamy texture and mouthfeel that fats usually provide, without adding calories or cholesterol.
- **Products**: Low-fat or fat-free dairy products, processed snacks, and creamy sauces.

6) Stabilizing Foam:

- **Role**: Some gums, like xanthan gum and guar gum, can stabilize foams in food products.
- **Mechanism:** Gums trap air in a stable structure, preventing the foam from collapsing, which is important for certain products with a foamy texture.
- **Products:** Beverages like whipped cream, meringues, beer foam, and aerated desserts.

7) Suspending Agent:

- **Role:** Gums are used to suspend solid particles in liquid, preventing them from settling.
- **Mechanism:** Gums increase the viscosity of a liquid, allowing solid particles to remain suspended and preventing them from separating out.
- **Products:** Fruit juices, smoothies, sauces with particulate ingredients (e.g., tomato ketchup with tomato pieces), and salad dressings.

8) Controlled Crystallization:

- **Role**: Gums help control sugar crystallization, which is particularly useful in candy production.
- **Mechanism:** Gums prevent the formation of large sugar crystals by interacting with sugar molecules, leading to smoother textures in candies and sweets.
- **Products**: Candies, fondants, and chewing gum.

9) Improving Stability in Frozen Foods:

- **Role**: Gums enhance the stability of frozen foods, especially in products that undergo freezing and thawing.
- **Mechanism**: Gums help prevent the formation of large ice crystals, which can negatively affect the texture of frozen foods. This leads to smoother, creamier textures in products like ice cream.
- **Products:** Ice cream, frozen desserts, frozen soups, and ready-to-eat frozen meals.

11) Reducing Syneresis (Water Loss):

- **Role:** Gums help reduce syneresis, the process where water separates from gels or solid food structures, leading to undesirable water release.
- **Mechanism:** By forming a stable gel or thickened structure, gums help prevent the release of water, ensuring better quality and longer shelf life.
- **Products:** Yogurt, cottage cheese, jams, and jellies.

11) Gluten-Free Baking:

- **Role:** Gums are essential in gluten-free baking, where they help mimic the textural properties that gluten normally provides in traditional baked goods.
- **Mechanism:** Gums like xanthan gum and guar gum can provide structure and elasticity to gluten-free dough, helping it hold together and preventing crumbling.
- **Products:** Gluten-free bread, cakes, muffins, and cookies.

12) Preventing Crystallization in Sugar Products:

- **Role**: In sugary products, gums can help prevent the crystallization of sugar, contributing to smooth textures.
- **Mechanism:** By interacting with sugar, gums prevent large sugar crystals from forming, leading to smoother textures in candies and syrups.
- **Products**: Caramel, toffee, syrups, and ice cream.

13) Health Benefits as Dietary Fiber:

- **Health Function:** Some gums, such as guar gum and xanthan gum, are soluble fibres that can contribute to digestive health and may have cholesterol-lowering effects.
- **Mechanism:** These gums act as prebiotics, stimulating the growth of beneficial gut bacteria and aiding in digestion.
- **Products:** Functional foods, fibre-enriched beverages, weight management foods, and health supplements.

5.8 SUMMARY:

Starch gelatinization is a fundamental process in food preparation and processing, offering diverse functionalities such as thickening, stabilizing, and textural modification. Understanding the science behind this process allows for the creation of a wide variety of food products with desirable textures and consistency.

Pectin is a versatile ingredient in food processing, providing essential functions such as gelling, thickening, stabilizing emulsions, retaining moisture, and enhancing fibre content. Its diverse functionalities make it crucial in a wide range of food products, from jams and jellies to beverages, dairy products, and gluten-free items. Beyond its structural roles, pectin also offers health benefits as a soluble fibre, supporting digestive health and providing dietary advantages. Gums are indispensable in the food industry for their ability to thicken, stabilize, emulsify, retain moisture, and enhance texture, while also contributing to the health benefits of certain food products. Their diverse functionalities make them crucial in a wide range of food and beverage applications.

5.9 TECHNICAL TERMS:

Retrogradation, gelling agent, emulsion, agitation, viscosity, Gelatinization, Translucency, Intra molecular, Catalyse, dextrin’s

5.10 SELF ASSESSMENT QUESTIONS:

1) Describe about structure of starch?
2) Discuss about the characteristics of some food starches?
3) What is gelatinization and what are the factors affecting it?
4) Write about modified food starches?
5) Explain the applications of pectins and gums?
6) What are various functional roles of pectins and gums?

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LESSON-6

BAKING PROCESS: CEREAL FLOURS, FLOUR MIXES -DOUGH AND BATTER, LEAVENING AGENTS-APPLICATIONS

OBJECTIVES:

After reading this chapter, students will be able to:

- Understand about baking process of various cereal flours and their mixes.
- Aware of the differences between dough and batter.
- Know about leavening agents and their applications structure.

STRUCTURE:

6.1 INTRODUCTION:

Baking is one of the oldest and most versatile cooking methods, using dry heat to transform raw ingredients into a variety of delicious and often complex foods. Traditionally performed in an oven, baking can also be done using hot ashes or heated stones. This technique has been a cornerstone of culinary practices across cultures for centuries, with bread being one of the most common and iconic baked goods.

Beyond bread, baking extends to cakes, pastries, cookies, pies, and savory dishes, showcasing its adaptability and wide appeal. The process often combines precision with creativity, making it both a science and an art. Whether for everyday sustenance or special occasions, baking holds a unique place in the world of cooking, offering a balance of texture, flavor, and visual delight in every creation.

Baking is a cooking method that utilizes dry heat, commonly in an oven, but it can also be done using hot ashes or heated stones. While bread is the most frequently baked item, a wide variety of foods can be prepared using this technique.

Role of Leavening Agents in Baking: Leavening agents are crucial in baking, as they cause dough to expand by releasing gas when mixed with liquid, acid, or heat. These agents contribute to the volume, texture, and crumb of baked goods. Common leavening agents include:

- **Chemical Agents**: Baking soda (sodium bicarbonate) is used for acidic recipes, reacting with the acid to produce carbon dioxide, which helps the dough rise. Baking powder, a mixture of sodium bicarbonate and a powdered acid, is ideal for non-acidic recipes.
- **Natural Agents**: Whipped egg whites, cream, active or instant dry yeast, and steam also serve as effective leavening agents.

6.2 BAKING PROCESS OF CEREAL FLOURS:

Baking with cereal flours generally involves combining flour, water, a leavening agent, and salt, followed by allowing the dough to rise and then baking it. The protein content in the flour significantly influences the dough's strength and the final product's characteristics.

Key Aspects of Baking with Cereal Flours:

Leavening Methods:

- **Baker’s Yeast or Sourdough Starter**: These can be used as leavening agents.
- **Dough Preparation**: A “straight dough” method involves mixing all ingredients simultaneously, whereas a “pre-ferment” method requires combining some flour and water with the leavening agent ahead of time.

Rising:

- Allowing the dough to rise one or more times enhances its flavor. Longer rising times yield more complex tastes.

Gluten Formation:

- Wheat flour contains proteins that form gluten when mixed with water. Gluten provides structure to baked goods, allowing the dough to stretch and trap gases produced by leavening agents during rising.

  Alternative Flours:

  - For those sensitive to gluten, alternative flours are being explored to partially or completely replace wheat flour.

6.3 BAKING PROCESS OF FLOUR MIXES:

The baking process for flour mixes involves the following key steps:

1. Mixing:

- Mixing incorporates heat into the dough, which can lead to oxidation and potential loss of flavor and color.
- Bakers use techniques like adding crushed ice or using refrigerated mixer bowls to maintain a cool dough temperature.

2. Fermentation:

- The dough is rested in a warm, humid environment to allow fermentation.
- During this stage, yeast and enzymes in the flour generate carbon dioxide and alcohol, causing the dough to expand.

3. Baking:

During baking, several chemical and physical changes occur, including:

- **Fats melting**
- **Gases expanding**
- **Microorganisms dying**
- **Sugars dissolving**
- **Proteins coagulating**
- **Starches solidifying**
- **Liquids evaporating**
- **Crust caramelizing and browning**

Water Absorption Consideration:

- Different flours have varying water absorption rates.

- It’s important to test the flour’s absorption factor by gradually adding water to a small flour sample until the desired dough consistency is achieved.


6.4 DOUGH:

Dough is a thick, malleable, and sometimes elastic paste made from grains, legumes, or chestnut crops. It is created by mixing flour with a small amount of water or other liquid and can include ingredients like yeast, fats, eggs, or flavorings.

General Uses:

Dough serves as the foundation for many foodstuffs, including:

- **Breads:** Rolls, loaves, flatbreads.
- **Pastries:** Pies, pastries, pizza crusts.
- **Desserts:** Cookies, cakes, biscuits.
- **Savory Items:** Dumplings, noodles, pasta.

Doughs can be made from various flours, such as wheat, rye, maize, rice, legumes, or almonds. They may also vary in composition, often enriched with eggs, fats, or other ingredients. While there’s no strict definition, most doughs exhibit **viscoelastic properties**.

Types of Dough:

Yeast-Leavened Dough:

- Used for breads, rolls, and some flatbreads.
- May or may not require kneading (e.g., ciabatta, focaccia).
- Ingredients like milk, eggs, sugar, or fats alter texture.
- Gluten provides structure and elasticity; gluten-free doughs need special handling.

Short Dough:

- Higher fat content, less water, and less gluten.
- Less elastic and prone to toughness if overworked.
- Common in cookies, pie crusts, and shortcrust pastry.

Quick Bread Dough

- Uses baking powder or baking soda as leavening agents.
- Includes cookies, cakes, biscuits, and more.
- May use batter instead of dough.

Techniques in Dough Production:

Yeast-Based Doughs:

- Mixed, kneaded, and left to rise.
- Often require a second kneading, shaping, and proofing.
- **Kneading** develops gluten for elasticity; proper temperature and timing are critical.

Pasta Dough:

- Made from dry dough, then kneaded and shaped through:
  - **Extrusion** (e.g., for macaroni).
  - **Rolling out** (e.g., for lasagna sheets).
  - **Hand-shaping** (e.g., gnocchi).
- May be cooked fresh or dried for storage.

Non-Yeast Doughs:

- Mixed but not kneaded or left to rise.
- Shaped and cooked directly, such as for biscuits or flatbreads.

Direct Heat and Fried Doughs:

- Some doughs are cooked over direct heat (e.g., tortillas on a griddle).
- Others are fried, creating a variety of culturally significant foods.

Semi-Liquid Batters:

- Used for items like pancakes, waffles, brownies, and muffins.
- Unlike bread dough, batters lack a gluten network for stabilization.

6.5 BATTER:

Batter is a flour mixture combined with liquid and additional ingredients like sugar, salt, and leavening agents. Unlike dough, batter has a higher liquid content, resulting in a pourable consistency that cannot be kneaded.

Batters are used for making pancakes, light cakes, fried food coatings, and a variety of batter breads. The word "batter" originates from the French term battre, meaning "to beat," reflecting the vigorous mixing often required in its preparation.

Preparation and Methods:

Base Ingredients:

1) Batters typically combine dry flour with liquids such as water, milk, or eggs.
2) Alternative methods include soaking grains in water and grinding them wet.

Leavening Agents:

1) Baking powder or baking soda is often used to aerate the batter, making it fluffier as it cooks.
2) Some batters are naturally fermented, adding flavor and texture.

Additional Aeration:

1) Carbonated liquids like sparkling water, soda, or beer can introduce air bubbles for a lighter batter.
2) Flavorful liquids such as wine, curaçao, brandy, or maraschino may be used as substitutes for water.

Viscosity:

- Batter consistency ranges from:
    1) **Heavy**: Adheres to an upturned spoon.
    2) **Thin**: Pourable or drop-from-a-spoon consistency, often called "drop batter."

Cooking Methods:

1) Heat is applied through frying, baking, or steaming to set the batter into a solid form.
2) Batters may be sweet (with sugar) or savory (with salt) and often include additional flavorings such as herbs, spices, fruits, or vegetables.

Beer Batter:

Beer is a popular ingredient in batters for frying foods due to its ability to:

- Introduce bubbles that add lightness and texture.
- Enhance flavor and color, depending on the beer type and quality.

Commonly Beer-Battered Foods:

- Fish
- Chips
- Onion rings

This method is widely used in countries such as Australia, New Zealand, the United States, Britain, Ireland, Germany, Iceland, and Russia.

Cuisines and Regional Variations:

Batters are a global culinary staple, known by various names:

- **Tempura** (Japan)
- **Pakoda** and **Dosa** (India)
- **Galapong** (Philippines)
- **Spoonbread** (United States)

Tips for Optimal Batters:

Ideal Coating:

- For fried foods, batters should be thick enough to adhere but not so thick as to become heavy.

Managing Gluten:

- Batters with wheat flour thicken over time as gluten develops.
- To minimize this effect:
  - Use ice water while mixing.
  - Incorporate alcohol (which doesn’t form gluten).
  - Prepare the batter at the last moment before use.

6.6 LEAVENING AGENTS:

A leavening agent, also known as a raising agent, is a substance used in doughs and batters that causes the mixture to lighten and soften by producing gas bubbles. These agents can be biological or chemical and are used to induce a foaming action. An alternative to leavening agents is the mechanical process of incorporating air into the mixture through techniques like kneading. The gas produced is typically carbon dioxide, although hydrogen is sometimes involved.

When dough or batter is mixed, the starch in the flour combines with the water to form a matrix, which is often supported by proteins like gluten or substances such as pentosans or xanthan gum. The starch gelatinizes and sets, trapping the gas bubbles within the mixture.

Biological Leavening Agents:

- Saccharomyces cerevisiae, a yeast that produces carbon dioxide, is found in baker's yeast, beer barm (live yeast), ginger beer, kefir, and sourdough starter.
- Clostridium perfringens, a bacteria that produces hydrogen, is used in salt-rising bread.

Chemical Leavening Agents:

Chemical leavening agents are mixtures or compounds that release gases when they react with moisture, heat, or each other. These agents generally consist of an acid (such as an organic acid with a low molecular weight) and a bicarbonate salt ($HCO3^-$). Once the reaction takes place, the compounds leave behind a chemical salt. Chemical leaveners are commonly used in quick breads, cakes, cookies, and other baked goods where biological fermentation is either impractical or undesirable.

Historical Context:

The use of chemical leavening agents dates back to the 1796 publication of *American Cookery* by Amelia Simmons, where pearl ash was mentioned as a leavening agent. In the 1800s, sour milk and carbonates were used. Significant advancements in chemical leavening occurred in the 1930s with the introduction of monocalcium phosphate. Other agents, such as sodium aluminium sulfate and disodium pyrophosphate, were developed and combined with sodium bicarbonate to release carbon dioxide in a controlled way.

Mechanical Leavening:

Mechanical leavening is another method that involves incorporating air into liquids through physical action, such as whisking. This is commonly seen in sponge cakes, where whipping egg whites creates a protein matrix that provides structure. The Chorleywood bread process, which uses both biological and mechanical leavening, is employed in bread production. While it is seen as an effective technique for dealing with soft wheat flours, its final product has been criticized for its quality.

Other Leavening Agents:

Steam and air are also used as leavening agents, expanding upon heating. This method requires high baking temperatures to turn water into steam, and the batter must be able to trap the steam until it sets. This type of leavening is used in foods like popovers, Yorkshire puddings, pita bread, and choux pastry, with similar effects seen in tempura.

6.7 APPLICATIONS:

Baking Methods and Techniques

1. Fermentation:

- **Process:** Yeast or other microorganisms feed on sugars in the dough, converting them into carbon dioxide gas and alcohol. The gas causes the dough to expand and rise, leading to the light, airy texture typical in bread and other yeast-leavened products.
- **Applications:**
    - **Bread:** Yeast fermentation is essential in breadmaking, especially for recipes like sourdough or pizza dough.
    - **Buns and Rolls:** Similar to bread, fermentation gives these products a soft texture.

2. Creaming:

- **Process:** This technique involves beating butter (or other fats) with sugar until the mixture is light and fluffy. The mechanical action incorporates air into the mixture, which helps create a tender texture in the final baked product.
- **Applications:**
    - **Cakes:** Most cakes, especially sponge cakes, use the creaming method to achieve lightness.
    - **Cookies:** This method also works well for cookies, providing them with a chewy or crisp texture depending on other ingredients.

3. Mixing:

- **Process:** Mixing ingredients together helps evenly distribute them, ensuring the dough or batter has a consistent texture. A mixer can be used for this, especially in industrial settings, while hand mixing is often used in home baking.
- **Applications:**
    - **Bread Dough:** When mixing bread dough, the aim is to form a uniform mixture with just the right amount of elasticity for the bread to rise properly.
    - **Cakes and Batters:** This method ensures that all ingredients like flour, eggs, and liquids are combined, with minimal over-mixing to avoid dense textures.

4. Rubbing In:

- **Process:** This technique involves using the fingers to rub flour and butter together until the mixture resembles breadcrumbs. It creates a light, flaky texture, ideal for products that need a crumbly texture.
- **Applications:**
    - **Shortcrust Pastry:** Common in tarts and pies, where a flaky texture is desired.
    - **Scones and Biscuits:** The rubbing-in method helps achieve the desired lightness and crumbliness.

5. Caramelization:

- **Process:** Caramelization occurs when sugar is heated and undergoes a chemical reaction that turns it brown. This imparts a rich, buttery flavor to the finished product.
- **Applications:**
    - **Pastry and Pies:** Often used in the making of tarts or pies where sugar is caramelized to enhance flavor.
    - **Candies and Sauces:** Caramelization is key in the creation of caramel candies, sauces, and glazes.

Different Types of Baking:

1. Oven Baking:

- **Method:** The most common form of baking, using an oven to create dry heat that surrounds food. This allows for consistent heat distribution and the ability to control temperature precisely.
- **Applications:**
    - **Cakes and Cookies**: Baked at specific temperatures to ensure even cooking and a soft, moist texture.
    - **Bread and Pastries**: A consistent temperature is essential for allowing yeast to rise without burning or over-drying the dough.

2. Baking on Hot Stones or Ashes:

- **Method:** Ancient baking methods involved cooking dough or meat over hot stones or in hot ashes, which retain heat and create an even temperature.
- **Applications:**
    - **Flatbreads:** Some traditional breads like naan or pita are baked on hot stones for a crisp outer texture.

- **Meats:** Meatloaf or meats with coatings, like stuffed chickens, can be baked in this way for a more rustic and smoky flavor.

3. Steam Baking:

- **Method:** In some cases, baking is done in a steamy environment, which helps create a moist, soft texture. This is often combined with high heat to create steam within the oven or on the food itself.
- **Applications:**
  - **Choux Pastry (e.g., éclairs):** Steam is essential for puffing up choux pastries, creating a hollow interior.
  - **Puddings or Certain Breads:** Steamed puddings or buns rely on moisture to achieve the right consistency.

Additional Techniques in Baking:

1. Blind Baking

- **Process:** This involves partially or fully baking a pie crust without filling, usually with pie weights to prevent it from rising or shrinking.
- **Applications:**
  - **Tarts and Pies:** Essential when making pies with wet fillings, ensuring the crust doesn't become soggy.

2. Glazing:

- **Process:** A thin, shiny coating is applied to the surface of baked goods, often after baking. This can be done with egg wash, milk, or sugar syrup.
- **Applications:**
  - **Pastries and Breads:** Glazing gives a shiny, attractive finish to items like croissants, breads, or danishes.

3. Sifting:

- **Process:** Flour and dry ingredients are sifted before use to ensure they are light and free from lumps. This helps create a smooth, even batter or dough.
- **Applications:**
  - **Cakes and Light Breads:** Sifting is especially important in delicate baked goods like sponge cakes to create a smooth texture.

These processes and techniques all contribute to the texture, flavor, and appearance of the final baked goods, whether they are sweet or savory.

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Baking is a versatile cooking method used to prepare a wide range of foods, including:

Baked Goods:

- Bread
- Cakes
- Pastries
- Pies
- Tarts
- Cookies
- Scones
- Crackers
- Pretzels

Meat

- Meatloaf
- Smaller cuts of meat
- Whole meats with stuffing or coatings

Baking Processes and Techniques:

Fermentation

- Yeast converts sugar into carbon dioxide gas, causing the dough to rise and become aerated.

Creaming

- Butter and sugar are beaten together until light and fluffy, helping to incorporate air into the mixture.

Mixing

- Ingredients are mixed using a mixer to form a consistent dough or batter.

Rubbing In

- Flour and butter are rubbed together with fingers until the mixture takes on the texture of breadcrumbs.

Caramelization

Sugar is browned, creating a rich, butter-like flavor. Baking can be carried out in various ways, including in an oven, using hot ashes, or on hot stones.

6.8 SUMMARY:

Baking is a method of cooking that involves using dry heat, usually in an oven, to turn dough or batter into baked goods. During the process, starches in the dough gelatinize, which helps create a firm crust while maintaining a soft interior. Key reactions such as caramelization and the Maillard reaction contribute to the development of a browned and flavorful exterior.

Baking requires precise control of temperature and time, ensuring that ingredients like flour, water, leavening agents, fats, eggs, milk, and sugars are combined in the right proportions for the desired texture and appearance. Here's a breakdown of key components in the baking process:

- **Flour and Water:** These form the base of the dough or batter. The flour's proteins (mainly gluten) combine with water to create a matrix that traps air and supports the structure of the baked product.
- **Leavening Agents:** Ingredients such as baker's yeast, baking soda, and baking powder release gas when activated. This gas becomes trapped in the dough, causing it to rise and become lighter.
- **Shortening (Fats and Oils):** Shortening makes dough easier to handle and contributes to a tender texture in the final product. It prevents the dough from being too tough or sticky.
- **Eggs:** Egg whites are essential for providing a light, airy texture in products like cakes or meringues. Egg yolks, on the other hand, add color, flavor, and richness to the dough.
- **Milk:** It adds moisture and enhances flavor, helping to soften the crumb of the final product.
- **Sugars:** Beyond sweetening, sugars help with the fermentation process (in yeast-leavened products), aid in browning, and contribute to texture by holding moisture.

Together, these ingredients undergo a transformation in the oven, with heat causing moisture to evaporate and gases to expand, resulting in a finished product that is both flavorful and appealing in texture.

6.9 TECHNICAL TERMS:

Here are some technical terms used in baking:

Preheat, Grease, Creaming, Beat, Fold, Knead, Blind baking, Cake flour, Ceramilization, Batter, Dough, Baking powder, crimp, dust, Bain marie, Aerate.

6.10 SELF ASSESSMENT QUESTIONS:

1) What is baking? Write about changes occur during baking process?

2) Write about leavening agent and its applications?

3) Explain about biological leavening agents?

4) Discuss about characteristics of dough and batter?

6.11 REFERENCE BOOKS:

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LESSON-7

PULSES AND LEGUMES: COMPOSITION, TOXIC CONSTITUENTS, PROCESSING, EFFECT OF COOKING

OBJECTIVES:

After reading this chapter, students will be able to:

- Learn about composition of Pulses and Legumes.
- Get knowledge about toxic constituents of Pulses and Legumes.
- Assess information about processing of Pulses and Legumes.
- Understand about changes occur in Pulses and Legumes with effect of cooking.

STRUCTURE:

7.1 INTRODUCTION:

Pulses and legumes are the edible seeds or fruits of plants in the **Leguminosae** family, commonly known as the legume family. These plants typically grow in pods, and their seeds are harvested for consumption. Pulses are an essential component of many diets worldwide due to their high nutritional value, including being rich in protein, fiber, vitamins, and minerals, as well as being relatively low in fat.

Some of the major pulses that play an important role in dietary habits include:

- **Red Gram Dal (Toor Dal):** A staple in many South Asian dishes, it is commonly used in soups, curries, and dals.
- **Bengal Gram Dal (Chana Dal):** Known for its nutty flavor, it is often used in Indian cuisine in various dishes such as soups and stews.
- **Black Gram Dal (Urad Dal):** This pulse is a key ingredient in making popular dishes like dosa, idli, and vada.

- **Green Gram Dal (Moong Dal):** Highly versatile, it is used in both sweet and savory dishes and is also consumed sprouted for its health benefits.
- **Masoor Dal (Red Lentils):** A common ingredient in soups and stews, it cooks quickly and has a mild flavor.

In addition to these commonly used pulses, other leguminous seeds are also vital to various diets. **Cowpea, Rajmah (Kidney Beans), Dry Peas,** and **Peanuts** are also significant contributors to human nutrition. Peanuts and soybeans, though part of the leguminous family, are categorized separately as oilseeds due to their higher oil content. These seeds are used for producing oils, snacks, and other products, including tofu and soy milk in the case of soybeans.

Nutritional Benefits of Pulses and Legumes:

- **High Protein Content:** Pulses are an excellent source of plant-based protein, making them a crucial dietary component for vegetarians and vegans.
- **Rich in Fiber:** Pulses contain a significant amount of dietary fiber, which helps in digestion and contributes to heart health by lowering cholesterol.
- **Low in Fat:** Most pulses are low in fat, especially saturated fat, making them heart-healthy options in various diets.
- **Vitamins and Minerals:** Pulses are rich in essential vitamins and minerals, including folate, iron, potassium, and magnesium, which contribute to overall health and well-being.

Overall, pulses and legumes are an invaluable part of global food systems, offering a sustainable source of protein and other essential nutrients. Their ability to fix nitrogen in the soil also makes them an environmentally friendly crop, contributing to soil fertility and promoting sustainable agricultural practices.

7.2 COMPOSITION OF PULSES AND LEGUMES:

COMPOSITION OF PULSES:

Pulses, belonging to the legume family, are highly nutritious seeds or fruits that play a key role in human diets across the world. They offer a variety of essential nutrients, making them an important source of protein, fiber, and other vital nutrients.

Energy Content:

Pulses provide approximately **340 calories per 100 grams**, which is comparable to the energy content found in cereals. This makes them a valuable source of energy, particularly in plant-based diets.

Carbohydrates:

Pulses are rich in carbohydrates, with **60% starch** content. In addition to starch, they contain **soluble sugars**, fiber, and **unavailable carbohydrates** like **oligosaccharides** (mainly from

the raffinose family). These oligosaccharides are not digested in the human body due to the lack of the enzyme **alpha-galactosidase**. As a result, they reach the lower intestine, where they are fermented by bacteria, producing gases like **carbon dioxide, hydrogen**, and **methane**, which can cause flatulence.

Protein:

Pulses are an excellent source of **protein**, containing about **20-25% protein**, which is nearly double the protein content of cereals. The proteins in pulses are mainly **globulins**, with some **albumin** present as well. Although pulses are deficient in the amino acid **methionine**, they are abundant in **leucine** and other essential amino acids such as **isoleucine, phenylalanine, threonine**, and **valine**. This makes pulses a complementary protein source to cereals, creating a more complete protein profile when consumed together. The quality of protein can be negatively impacted if pulses are infested.

Fats:

On a moisture-free basis, pulses contain about **1.5% fat**, primarily in the form of **polyunsaturated fatty acids**, including **linoleic acid** and **linolenic acid**. When combined with cereals, pulses provide the necessary essential fatty acids for the diet. However, these fats are prone to **oxidative rancidity** during storage, which can lead to a loss of protein solubility, off-flavors, and reduced nutritional quality. Pulses also contain small amounts of **oleic acid, stearic acid**, and **palmitic acid**.

Minerals:

Pulses are rich in a variety of essential minerals, including **calcium, magnesium, zinc, iron**, and **potassium**. Typically, pulses provide **6-7 mg of iron per 100 grams**, with **moth beans** being particularly high in iron. Pulses also contain **80% of phosphorus**. However, **phytin**, a form of phosphorus, can bind to proteins and minerals, making them less available for absorption by humans and animals. Processing methods like **soaking, cooking, germination**, and **fermentation** can reduce or eliminate phytin, enhancing the bioavailability of these minerals.

Vitamins:

Pulses are a rich source of **B-complex vitamins**, particularly:

- **Thiamine (B1)**
- **Folic acid (B9)**
- **Pantothenic acid (B5)**

Legumes like **red gram**, **rajmah**, and **moth beans** are especially high in **folates**. However, pulses do not contain **vitamin A** or **vitamin C**. Some **germinated pulses** may contain small amounts of **vitamin C**. Additionally, **antioxidant activity** varies across different pulses:

- **Rajmah** and **soybeans** exhibit better antioxidant properties than most other pulses.

- **Bengal gram dal** (chana dal) has the lowest antioxidant activity.
- **Boiling and pressure cooking** can increase the **phenolic content** in pulses such as **green gram** and **bengal gram**, while **soaking and sprouting** increase the phenolic content in **green gram**.

Glycaemic Index:

Pulses such as beans, peas, lentils, and others generally have a **low glycaemic index (GI)**. This means they cause a slower, more controlled increase in blood sugar levels. The low GI of pulses is attributed to their high **protein**, **fiber**, and **enzyme inhibitor** content, which collectively help slow down carbohydrate digestion and absorption. This makes pulses an ideal food for managing blood sugar levels, particularly in individuals with diabetes.

Conclusion:

Pulses are highly nutritious and versatile foods, rich in **protein**, **fiber**, **minerals**, and **vitamins**, and they provide a valuable source of **energy**. Their high protein content makes them a perfect complement to cereals, creating a balanced and complete protein profile. Additionally, their **low glycaemic index** makes them ideal for controlling blood sugar levels. By using proper processing techniques like soaking, germinating, and cooking, the bioavailability of nutrients in pulses can be further enhanced, contributing to a healthier and more sustainable diet.

COMPOSITION OF LEGUMES:

Legumes are nutritionally rich and consist of a balanced composition of macronutrients, micronutrients, and bioactive compounds. Their unique composition makes them an essential part of a healthy diet and a valuable food crop. Below is an overview of the main components of legumes:

1) **Macronutrients**

   a) **Carbohydrates (50–65%)**

   Legumes are a rich source of complex carbohydrates, including:

   Starch: The primary storage carbohydrate.

   Dietary Fiber: Soluble and insoluble fiber that supports digestion and lowers cholesterol.

   Oligosaccharides: Such as raffinose and stachyose, which may cause flatulence but are beneficial as prebiotics.

   b) **Proteins (20–40%)**

   High-quality plant-based protein with essential amino acids like lysine (limited in cereals).

   Limiting amino acid: Methionine.

   Legumes are a key protein source in vegetarian and vegan diets.

c) Fats (1–10%)

Most legumes are low in fat, except for oil-rich legumes like peanuts and soybeans.

Contains:

Unsaturated Fats: Healthy fats, especially in soybeans and peanuts.

Essential Fatty Acids: Linoleic acid and linolenic acid.

2) Micronutrients:

a) Vitamins

Water-soluble vitamins: Rich in B-complex vitamins (e.g., folate, thiamine, niacin, riboflavin).

Fat-soluble vitamins: Soybeans and peanuts contain small amounts of vitamin E and K.

b) Minerals

High in essential minerals:

Iron: Important for oxygen transport.

Calcium: Supports bone health.

Magnesium: Vital for energy metabolism.

Zinc: Supports immune function.

Potassium: Helps maintain fluid and electrolyte balance.

3) Phytochemicals:

Phenolic Compounds: Antioxidants that help combat oxidative stress.

Saponins: May have cholesterol-lowering effects.

Phytosterols: Support cardiovascular health.

Isoflavones: Found in soybeans, act as phytoestrogens with potential health benefits.

4) Water:

Moisture content of dried legumes is low (10–12%), increasing shelf stability.

5) Anti-nutritional Factors

While nutritious, legumes also contain some anti-nutritional factors, such as:

- Phytates
- Lectins
- Protease inhibitors
- Tannins
- Cyanogenic glycosides

These factors can reduce nutrient absorption but are mitigated through proper processing (e.g., soaking, cooking, fermenting).

6) Energy Content:

Legumes provide moderate to high energy, ranging from 300–400 kcal per 100 g (dry weight), depending on the type and fat content.

Variability in Composition

The exact composition varies depending on the type of legume. For example:

Soybeans: High in protein and fat.

Chickpeas and lentils: Rich in carbohydrates and fiber.

Peanuts: High in fat, especially unsaturated fatty acids.

In summary, legumes are a nutrient-dense food, offering a well-rounded profile of macronutrients, micronutrients, and bioactive compounds essential for health and well-being.

7.3 TOXIC CONSTITUENTS OF PULSES AND LEGUMES:

While legumes are an excellent source of nutrition, they contain certain natural toxins and anti-nutritional factors that can cause health issues if not prepared properly. Below are some common toxic constituents found in pulses:

1) Lectins (e.g., Phytohaemagglutinins)

- **Found in:** Kidney beans, other common beans.
- **Effects:** Lectins can cause **gastrointestinal distress**, including nausea, vomiting, and diarrhea. Severe cases may lead to **red blood cell clumping**.
- **Mitigation: Soaking** and **boiling** the beans effectively destroy lectins, making them safe to consume.

2) Protease Inhibitors:

- **Found in:** Soybeans, lentils, and other legumes.
- **Effects:** These inhibitors interfere with protein digestion by blocking enzymes like **trypsin** and **chymotrypsin**, which are essential for breaking down proteins.
- **Mitigation:** Cooking legumes deactivates these protease inhibitors, making protein digestion possible.

3) Saponins:

- **Found in:** Chickpeas, soybeans, and other legumes.
- **Effects:** Saponins can cause **gastrointestinal irritation** and may reduce nutrient absorption if consumed in large quantities.

- **Mitigation:** Cooking and processing methods help reduce saponin levels, making them safe for consumption.

4) **Phytates (Phytic Acid):**
   - **Found in:** All legumes.
   - **Effects:** Phytates bind to essential minerals like **calcium, iron**, and **zinc**, reducing their **bioavailability** and making them harder for the body to absorb.
   - **Mitigation: Soaking, fermentation**, and **sprouting** can significantly reduce phytate levels and enhance mineral absorption.
5) **Oligosaccharides (e.g., Raffinose, Stachyose):**
   - **Found in:** Lentils, chickpeas, and other legumes.
   - **Effects:** These complex sugars can cause **flatulence** and **digestive discomfort** due to fermentation by gut bacteria.
   - **Mitigation: Soaking** and **cooking**, along with the use of digestive enzymes like **alpha-galactosidase** (found in products like Beano), help mitigate the effects.
6) **Cyanogenic Glycosides:**
   - **Found in:** Lima beans, and certain species of other beans.
   - **Effects:** Cyanogenic glycosides release **cyanide** when metabolized in the body, leading to toxicity.
   - **Mitigation: Proper cooking** destroys these cyanogenic compounds, making the beans safe to eat.
7) **Tannins:**
   - **Found in:** Lentils, fava beans, and certain other legumes.
   - **Effects:** Tannins can **interfere with protein and iron absorption**, which may reduce the bioavailability of these nutrients.
   - **Mitigation: Soaking** and **cooking** can reduce tannin levels, making the legumes safer to consume.
8) **Favism-inducing Compounds (Vicine and Convicine):**
   - **Found in:** Fava beans.
   - **Effects:** These compounds can cause **hemolytic anemia** in individuals with a deficiency in **glucose-6-phosphate dehydrogenase (G6PD)**.
   - **Mitigation:** Individuals with G6PD deficiency should avoid consuming fava beans to prevent health complications.

9) **Alkaloids (e.g., Lupinine):**

- **Found in:** Lupin beans.
- **Effects:** Alkaloids like lupinine can cause **neurological effects** such as dizziness, confusion, and other symptoms if consumed in high quantities.
- **Mitigation: Proper processing** and **soaking** can reduce alkaloid levels, making lupin beans safe for consumption.

10) **Goitrogens:**

- **Found in:** Soybeans.
- **Effects:** Goitrogens can interfere with **thyroid function** by inhibiting iodine uptake, potentially leading to thyroid problems.
- **Mitigation: Cooking** and moderate consumption can significantly reduce the goitrogenic effects.

Additional Toxic Constituent: Trypsin Inhibitors:

Trypsin inhibitors are proteins that inhibit the activity of the enzyme **trypsin**, which is crucial for digesting proteins in the gut. They are present in various pulses, including **red gram**, **Bengal gram**, **cowpea**, **soybean**, and **peas**. These inhibitors can reduce the digestibility and utilization of dietary proteins and can lead to issues such as **pancreas enlargement** and **growth retardation** in animals.

- **Mitigation:** Trypsin inhibitors are heat-labile, meaning they can be deactivated by **moist heat treatments**, such as **pressure cooking**. Autoclaving at **120°C** for 15-30 minutes is effective at inactivating these inhibitors in most legumes. However, more drastic heat treatment may be required for soybeans and kidney beans.

Lathyrogens and Lathyrism:

Lathyrogens, particularly found in **Lathyrus sativus** (commonly known as **Khesari dal**), can cause a disease known as **Lathyrism**. This neurotoxin, **B-N-Oxalyl-L-β-diaminopropionic acid**, can cause **muscular rigidity** and **paralysis** if consumed in large quantities, particularly when it becomes the main source of nutrition. Symptoms may develop in stages, starting with difficulty walking and progressing to complete immobility.

- **Mitigation:** The neurotoxin can be removed by **steeping** or **parboiling** the seeds before consumption. Avoiding excessive reliance on this pulse can prevent Lathyrism.

Conclusion:

While legumes are a valuable food source, they contain certain toxic compounds that can pose risks to health if not properly prepared or consumed in excessive amounts. **Lectins**, **protease inhibitors**, and other toxins can be safely mitigated through appropriate preparation techniques such as **soaking, boiling, fermentation**, and **sprouting**. By following proper cooking methods, the health benefits of legumes can be enjoyed while minimizing the potential risks from their toxic constituents.

7.4 PROCESSING OF PULSES AND LEGUMES:

Proper processing of pulses and legumes is essential to enhance their nutritional value, digestibility, and safety. Various methods are used, including milling, soaking, germination, fermentation, and more. Each method helps to reduce anti-nutritional factors and improve the overall quality of pulses for human consumption.

1. Milling or Decortication:

Milling or decortication involves removing the outer husk or seed coat, which is tightly bound to the cotyledons through a layer of gum and lignin. To facilitate this, the seeds are dried to a critical moisture level, making the husk brittle and easy to remove by abrasion.

- **Dry Milling:** This method produces a **hemispherical-shaped dal**, which softens quickly when cooked and has a good flavor.
- **Wet Milling:** The dal obtained by wet milling is generally **flat**, with a depression in the center due to shrinkage. It softens more slowly during cooking.
- **Oil Pre-treatment:** For pulses like pigeon pea, where the seed coat is more tightly bound, a pre-treatment using edible oil (such as linseed oil) is applied. The grains are mixed with oil and sun-dried, which helps loosen the husk.
- **Milling Yield:** Typically, milling yields about **82%** of the final product, depending on the variety and seed coat percentage.

2. Soaking:

Soaking is an important process for many pulses, especially those with hard outer coverings. The process helps to soften the pulses, making them easier and quicker to cook. It also improves their digestibility.

- **Soaking Process:** Water enters through the hilum or scar where the bean is attached to the pod. It then spreads around the seed, causing the seed coat to wrinkle, which is eliminated as the cotyledons swell.
- **Soaking Methods:**
    - **Cold Water Soaking:** Pulses like rajmah and beans are soaked overnight in cold water.
    - **Warm Water Soaking:** Some pulses, such as green gram and lentils, can be soaked in warm water (60-70°C) for 4-5 hours.
    - **Effect on Nutrients:** Soaking reduces the levels of **phytic acid** and **oligosaccharides**, improving nutrient availability.
    - **Impact of Hard Water:** Hard water makes it harder for water to penetrate the seed coat. Soaking in **salt solution** can help loosen the seed coat, enhancing absorption.

3. Germination:

Germination involves soaking the seeds and allowing them to sprout, which enhances nutrient availability and reduces anti-nutritional factors.

- **Germination Process:** After soaking, seeds are tied in cotton cloth and kept moist by sprinkling water 2-3 times a day. Germination typically takes 1-2 days.
- **Time Variations:** The germination process is faster in warm weather (summer) compared to cooler months (winter).
- **Benefits:** Germinated legumes have improved nutritional content, including increased levels of certain vitamins and amino acids.

4. Fermentation:

Fermentation is a biological process that involves microbial action, breaking down proteins and improving digestibility. It also enhances the bioavailability of vitamins (especially **B and C vitamins**) and reduces toxic substances.

- **Impact on Digestibility:** Fermentation breaks down legume proteins, making them easier to digest.
- **Nutritional Improvement:** Fermentation also boosts the availability of **essential amino acids**, improving the overall nutritional quality of the legumes.
- **Examples:** Foods like **idli** and **dosa** are made using fermented legumes, which have better nutritional quality due to this process.

5. Parching and Puffing:

Parching and puffing are traditional methods of roasting legumes to enhance flavor and texture.

- **Parching Process:** Grains like **Bengal gram** and **peas** are sprinkled with water, mixed with heated sand, and roasted at temperatures between 200-250°C for 2-3 minutes. This method produces a **highly-acceptable product**.
- **Puffing Process:** The puffing process involves soaking seeds, mixing them with heated sand (250°C), and quickly heating them. Common legumes prepared in this manner include **chickpeas** and **field peas**.
- **Benefits:** Parched Bengal gram has been successfully used to treat **protein-calorie malnutrition** in children.

6. Extrusion:

Extrusion is a high-heat, high-pressure process used to produce nutritious food products from cereal and legume flour blends.

- **Extrusion Process:** Legume and cereal flours are blended, then extruded at temperatures ranging from **140-200°C**, at high pressure with moisture content less than **20%**.
- **Time and Temperature:** The product is cooked quickly (30-60 seconds) and then forced out of the extruder through various dies, dried on conveyor belts to produce the final product.

By following proper processing methods like soaking, cooking, fermentation, and sprouting, the toxic constituents in legumes can be minimized, making them safe and highly nutritious for consumption.

7.5 EFFECT OF COOKING:

Cooking pulses and legumes plays a crucial role in improving their safety, digestibility, and nutritional value. However, it also results in some changes that affect their nutrient content, including the breakdown of anti-nutritional factors, protein quality, mineral availability, and the color of the legumes.

1. Anti-Nutritional Factors:

- Uncooked pulses and legumes contain **anti-nutritional factors** that can be toxic if consumed in large quantities. Cooking helps in reducing or eliminating these factors, though some may remain in the cooked product.
- **Trypsin Inhibitors:** These are proteins that inhibit the enzyme trypsin, reducing protein digestion. Cooking at 90°C for a sufficient time causes the complete **disappearance** of trypsin inhibitors. This improves protein digestibility.
- **Haemagglutinins (Lectins):** These are carbohydrate-binding proteins that can cause gastrointestinal distress and red blood cell clumping. Like trypsin inhibitors, haemagglutinins are **eliminated** by cooking at 90°C.
- **Polyphenolic Compounds:** While trypsin inhibitors and haemagglutinins disappear with cooking, **polyphenolic compounds** (like tannins) decrease but **are still present** in the cooked legumes. These compounds can be found in the **cooking liquor** and may contribute to the color and flavor. Legumes such as **red kidney beans, black gram, and soybeans** tend to have higher levels of polyphenolic compounds.

2. Protein Quality:

- Heating pulses and legumes improves protein quality by reducing anti-nutritional factors, increasing **digestibility**, and enhancing the **availability of amino acids**.
- **Improvement by Cooking:** Cooking increases the bioavailability of essential amino acids, making proteins in legumes more digestible.

- **Effect of Heat Treatment:** Excessive heat can **reduce protein quality**, especially by affecting the levels of essential amino acids like **methionine**, which is the most important amino acid in legumes.
- **Roasting** causes a significant loss of **lysine** compared to **boiling** or **pressure cooking**. However, moist heat (e.g., boiling or pressure cooking) is better at preserving protein quality than dry heat (e.g., roasting).

3. Minerals:

Cooking pulses and legumes generally has little effect on the levels of certain minerals:

- **Calcium, Magnesium, and Total Iron:** The cooking process does not significantly alter the levels of these minerals in the final cooked product. Therefore, pulses remain a good source of these essential minerals after cooking.

4. Vitamins:

- **Thiamine (Vitamin B1):** The loss of **thiamine** during cooking is a common occurrence, particularly when high temperatures are used. The extent of loss depends on the cooking time and temperature.

5. Colour Changes:

Cooking also affects the appearance of pulses, particularly their color:

- **Sodium Metabisulphite:** This compound is commonly used to **maintain the color** of **lentils** and other legumes during processing. It helps in preserving the natural color and preventing the beans from becoming overly dark.
- **Color Darkening:** Other legumes tend to become **darker** during cooking, which may be due to the breakdown of polyphenolic compounds or other components in the seed.
- **Anti-nutritional factors** (trypsin inhibitors, haemagglutinins, polyphenolic compounds) are reduced with cooking, but some, like polyphenolic compounds, may still be present in the cooking liquid.
- **Protein quality** improves with cooking, though excessive heat may degrade essential amino acids.
- **Mineral content** of calcium, magnesium, and iron remains largely unchanged during cooking.
- **Vitamins**, especially **thiamine**, can be lost during cooking.
- **Color** changes during cooking, with some legumes darkening and others requiring preservatives like sodium metabisulphite.
- **PCMP number** correlates with cooking time, influencing texture and cooking characteristics of pulses.

By understanding these effects, appropriate cooking methods can be chosen to maximize the nutritional benefits of pulses and legumes while minimizing losses.

7.6 SUMMARY:

Legumes and pulses are essential for food security, nutrition, agriculture, and environmental sustainability. They offer a wide range of benefits, making them a crucial component of diets globally and an integral part of sustainable agricultural practices.

Nutritional Contributions:

Legumes are a rich source of:

- **Proteins:** They are excellent plant-based protein sources, essential for growth, repair, and overall health.
- **Vitamins and Minerals:** Legumes provide a variety of vitamins (such as B-vitamins) and minerals like iron, magnesium, and zinc, contributing to overall well-being.
- **Low in Fat:** Most legumes are naturally low in fat, making them a healthy choice for weight management and reducing the risk of cardiovascular diseases.

Food Security:

- Legumes are critical to ensuring food security, especially in regions where protein sources are scarce or expensive. They provide a cost-effective, sustainable alternative to animal-based proteins.

Their nutritional profile, ability to enhance soil health, and role in sustainable farming make them a key factor in achieving food security and promoting a healthier, more sustainable future for all.

7.7 TECHNICAL TERMS:

Cowpea, Rajmah (Kidney Beans), Dry Peas, Peanuts, Toor Dal, Urad Dal, Moong Dal, Chana Dal, Hytohaemagglutinins, Isoleucine, Phenylalanine, Threonine**,** Valine.

7.8 SELF ASSESSMENT QUESTIONS:

1) Write about composition of pulses and legumes
2) Discuss about toxic constituents of pulses
3) Describe about processing of pulses
4) Explain about effect of cooking on pulses

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LESSON-8

VEGETABLES AND FRUITS: CLASSIFICATION, COMPOSITION, PIGMENTS AND FLAVORS CONSTITUENTS-COOKING EFFECT, BROWNING REACTION

OBJECTIVES:

After going through this lesson students will understand:

- Classification and composition of vegetables and fruits.
- Pigments and flavour constituents.
- Effect of cooking.
- Browning reactions.

STRUCTURE:

8.1 INTRODUCTION:

Vegetables are edible parts of plants that are commonly consumed as a primary component of meals, either raw or cooked. While the term "vegetable" has evolved to refer to these plant parts, it often implies foods served as part of the main dish. Vegetables contribute numerous essential nutrients to the diet, while also enhancing the visual appeal and taste of meals through their color, texture, and flavor.

Several factors influence vegetable consumption, including their high cost, the time required for preparation, and a lack of awareness about their health benefits. In some cases, seasonal availability or geographical limitations further reduce vegetable intake. Their perishable nature also means that without proper storage, consumption may be restricted.

The different parts of plants-such as roots, stems, leaves, and flowers-can be consumed as food. Understanding the botanical classification of these parts is crucial as it provides insight into their structure and composition, which can influence their nutritional value and how they should be prepared or cooked. The content of water, protein, vitamins, minerals, and carbohydrates varies across these plant parts.

Fruits, on the other hand, are the mature ovaries of plants, often accompanied by seeds, and are generally sweet, juicy, and aromatic. They can also exhibit a range of flavors and textures, making them a versatile addition to meals.

Despite their botanical differences, vegetables and fruits share similarities in their cultivation, harvesting, storage, and processing methods. Interestingly, many foods we classify as vegetables, such as tomatoes, cucumbers, eggplants, and peppers, are botanically fruits because they contain seeds. However, the distinction between vegetables and fruits is generally based on culinary usage: items typically consumed with the main course are considered vegetables, while those usually eaten alone or as desserts are classified as fruits.

India, with its diverse and favorable climate, is a major producer of both tropical and temperate fruits and vegetables, yielding approximately 53 million tonnes annually. Vegetables are integral to meals, not only for their nutritional value but also for their ability to add color, texture, and flavor, making meals more visually appealing and enjoyable. By choosing vegetables with varying colors, textures, and flavors, meals can be customized to meet aesthetic and taste preferences.

In summary, fruits are the sweet, often juicy products of plants, typically containing seeds and surrounded by fleshy or pulpy tissue. They come in a wide variety of flavors, colors, and textures, making them a delicious and important part of a balanced diet.

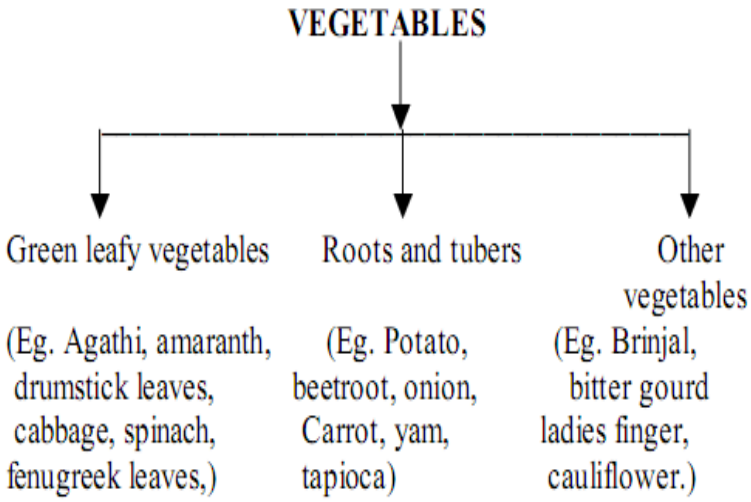
8.2 CLASSIFICATION OF VEGETABLES AND FRUITS:

8.2.1 Vegetables:

Vegetables can be classified based on the plant part they originate from, such as green leafy vegetables, roots and tubers, and other categories. This classification helps in understanding the different types of vegetables and their characteristics. Additionally, vegetables can be grouped according to their color, which can indicate the presence of specific nutrients, or by their nutritional value.

From a nutritional perspective, vegetables are commonly categorized into three main groups:

- **Protective vegetables**: These vegetables are rich in vitamins, minerals, and antioxidants that help protect the body from diseases. Examples include leafy greens like spinach and kale, which are high in vitamins A, C, and K.
- **Energy-giving vegetables**: These vegetables are higher in carbohydrates, particularly starch, and provide energy. Examples include potatoes, sweet potatoes, and other tubers.
- **Body-building vegetables**: These vegetables are rich in proteins and help in the growth and repair of body tissues. Examples include legumes like peas and beans.
- Each group offers specific benefits, contributing to a balanced and healthy diet.



8.2.2 Fruits:

A fruit is the mature ovary of a plant that contains seeds. The edible part of most fruits is the fleshy pericarp or the vessel surrounding the seeds. Fruits are typically characterized by their sweet or acidic flavor due to their natural sugar and acid content.

Fruits can be classified based on their shape, cell structure, seed type, or natural habitat. One common system of classification divides fruits into the following groups:

- **Berries**: These are small, juicy fruits with a fleshy texture. Examples include strawberries, gooseberries, blackberries, raspberries, blueberries, and cranberries.
- **Citrus Fruits**: These are juicy, acidic fruits with a thick rind. Examples include sweet limes, oranges, tangerines, sour oranges, limes, lemons, and grapefruits.
- **Drupes**: Fruits with a single seed enclosed within a hard pit. Examples include apricots, sweet cherries, peaches, and plums.
- **Grapes**: Includes green grapes, black grapes, and seedless varieties.
- **Melons**: Large, fleshy fruits with a high water content. Examples include musk melons and watermelons.

- **Pomes**: Fruits with a core containing seeds surrounded by fleshy tissue. Examples include apples and pears.
- **Tropical and Subtropical Fruits**: Fruits that thrive in warm climates. Examples include amla, avocado, bananas, dates, guava, jackfruit, mango, jambu fruit, papaya, passion

8.3 COMPOSITION OF VEGETABLES AND FRUITS:

8.3.1 Vegetables:

Gross composition of fruits and vegetables:

The composition of vegetables and fruits depends not only on botanical variety, cultivation practices, and weather but also on the degree of maturity prior to harvest and the condition of ripeness, which continuous after harvest and is influenced by storage conditions.

Vegetables are a diverse group of plant foods classified by their nutritional composition and the part of the plant they come from. Below is an overview of their composition based on the type of vegetable:

1. Green Leafy Vegetables:

- **Nutritional Highlights**:
  - Rich in **β-carotene**, ascorbic acid, folic acid, calcium, iron, and fiber.
  - Poor in protein and carbohydrates.
  - Contain chlorophyll, masking carotenoids, but these are converted to vitamin A in the body.
  - High in antioxidants like **β-carotene**.
  - Excellent sources of **B-vitamins** (riboflavin and folic acid), although drying and withering may reduce these vitamins.
  - Rich in **vitamin C**, which can substitute fruits when needed (e.g., drumstick leaves, coriander). However, heat reduces vitamin C content.
  - Good sources of **iron** to prevent anemia (e.g., amaranth, fenugreek).
  - Contain **calcium**, especially agathi, colocasia, and drumstick leaves.
- **Examples**: Drumstick leaves, cabbage, coriander, fenugreek leaves, amaranth leaves.

2. Roots and Tubers:

- **Nutritional Highlights**:
  - High in **carbohydrates**, making them a significant energy source.
  - Rich in **carotene** (carrots, yellow yam) and **vitamin C** (potatoes).
  - Tapioca and yams are good sources of **calcium**.
  - Poor in iron, protein, and B-vitamins.

- **Nutritive Values**:
  - Higher calorie content due to starches.
  - Fair sources of **vitamin C** but low in other nutrients like iron and calcium.
- **Examples**: Carrots, potatoes, yams, tapioca.

3. Other Vegetables

- **Nutritional Highlights**:
  - Provide **dietary fiber**, contributing to digestive health.
  - Fairly good sources of vitamins and minerals.
  - Contain high moisture, making them highly perishable.
  - Tomatoes are rich in **lycopene**, a powerful carotenoid antioxidant.
  - Cluster beans are especially rich in **iron, carotenoids**, and **vitamin C**.
- **Examples**: Brinjal (eggplant), okra (ladies' finger), cauliflower, cucumber, gourds, tomatoes, cluster beans.

8.3.2 Fruits:

Fruits are an essential component of a healthy diet, offering a variety of nutrients, flavors, and textures. Below is a detailed composition of different fruit types:

1. Berries:

- **Structure**: Fruits with layers of pericarp (fruit coat) that are mostly homogeneous except for the outer skin.
- **Characteristics**: Pulpous, juicy, and contain seeds embedded within the pulp mass. The fragile cell structure is susceptible to damage from rough handling or freezing.

2. Citrus Fruits:

- **Structure**: Belonging to the genus *Citrus*, these fruits come from evergreen aromatic shrubs or trees, often with thorny branches.
- **Characteristics**: Known for their bright color, pleasing flavor, and sweetness. Commonly consumed raw or as juice.
- **Examples**: Oranges, lemons, limes.

3. Drupes:

- **Structure**: Edible fruits with a thin outer skin, juicy flesh, and a single seed enclosed in a hard stone.
- **Examples**: Apricots, cherries, peaches, plums.

4. Melons:

- **Structure**: Part of the *Cucurbitaceae* family, melons are mostly water (94%) and sugars (5%).
- **Characteristics**: Commonly eaten raw; seeds, when stripped of their hard coats, can be consumed or used to produce edible oil.
- **Examples**: Watermelon, musk melon.

5. Pomes:

- **Structure**: Derived from apple and pear trees, these fruits have an enlarged flower receptacle surrounding the ovaries. This forms the edible, juicy part of the fruit, enclosing the seed cells.
- **Examples**: Apples, pears.

Nutritional Highlights:

Vitamins and Antioxidants:

- **Vitamin C**: Citrus fruits, guavas, and gooseberries are excellent sources. Cashew fruits are also rich in vitamin C.
- **β-Carotene**: Mangoes (especially Alphonso), papayas, and Indian dates are rich sources. Mango varieties like Banginapalli and Peddha Rasaalu offer significant β-carotene content.
- **Antioxidants**: Apples, pears, cherries, and citrus fruits contain flavonoids that combat oxidative stress.

Macronutrients:

- **Carbohydrates**: Ripe fruits, particularly bananas, provide energy due to their high sugar content (sucrose, fructose, glucose).
- **Proteins and Fats**: Generally low, except for avocados, which contain 13.8% fat. ω-3 fatty acids are found in plums, guavas, and papayas.

Minerals and Fiber:

- **Iron**: Found in dry fruits, custard apples, and watermelon.
- **Other Minerals**: Sodium, potassium, and magnesium are present, but calcium content is low.
- **Fiber**: Contributes to dietary fiber intake and promotes digestive health.

8.4 PIGMENTS:

The vibrant colors of fruits and vegetables play a significant role in their appeal in our diets. These colors arise from pigments that are primarily located within cellular plastid inclusions,

such as chloroplasts and chromoplasts, and to a lesser extent, dissolved in fat droplets or water within the cell's protoplast and vacuole. In some cases, water-soluble pigments are specifically dissolved in the vacuoles rather than being uniformly distributed throughout the cell.

Pigments in fruits and vegetables are categorized into two main groups: fat-soluble pigments, including chlorophylls and carotenoids, and water-soluble pigments, such as anthocyanins and anthoxanthins. The latter group, which also includes tannins, is part of the flavonoid family. These pigments significantly influence the vibrant hues of many vegetables, enhancing their visual and dietary appeal. Fat-soluble pigments are primarily found in plastids within the protoplasm, while water-soluble pigments are typically confined to vacuoles.

A) Water-insoluble pigments:

Water-Insoluble Pigments:

Chlorophyll: The green pigments found in plant leaves and stems are primarily stored in structures called chloroplasts, which are located near the cell walls. Along with chlorophyll, these structures also contain some carotenes and xanthophylls. Two types of chlorophyll have been identified:

- **Chlorophyll A**: This pigment has a deep blue-green color.
- **Chlorophyll B**: This pigment is a dull yellow-green.

In most plants, the ratio of chlorophyll-A to chlorophyll-B is approximately 3:1. Chlorophyll-A is found in the florets of blue-green broccoli, while chlorophyll-B is more concentrated in the stalks. These pigments are largely insoluble in water and are especially abundant in unripe fruits, where they overshadow other pigments. Chlorophyll is present in a variety of foods such as green leafy vegetables, peppers, beans, peas, and chillies.

Carotenoids: Carotenoids are a diverse group of fat-soluble pigments that come in yellow, orange, and red hues. They are widely distributed across nature and are primarily found in the chloroplasts of green leaves. Although carotenoids are present in these leaves, their color is often hidden by the dominance of chlorophyll. Key carotenoids include:

- **α-carotene**
- **β-carotene**
- **γ-carotene**
- **Xanthophyll**
- **Cryptoxanthin**

Carotenoids are responsible for the vibrant orange colors seen in carrots, corn, apricots, peaches, citrus fruits, and squash. The red pigment **lycopene**, found in tomatoes, watermelon,

and apricots, is an isomer of carotene. The yellow-orange pigments, such as **xanthophylls**, are found in corn, peaches, paprika, and squash. Xanthophylls are oxygen-containing derivatives of carotene. Carotenoids generally do not occur in isolation but are typically found together within plant cells.

Carotenoids are important because they act as precursors to vitamin A. **β-carotene**, one of the most well-known carotenoids, is particularly significant as it is converted into two molecules of vitamin A in the body. Other carotenoids, like **α-carotene**, **γ-carotene**, and **cryptoxanthin**, also contribute to vitamin A production, but due to slight differences in their chemical structure, they each provide only one molecule of vitamin A per molecule of carotenoid.

B) Water-Soluble Pigments:

Water-Soluble Pigments:

Pigments containing the phenolic group include anthocyanins, anthoxanthins, leucoanthoxanthins, catechins, quinones, and betalins. These are collectively known as **flavonoids**.

Flavones and Flavonols:

Flavones and flavonols are crystalline yellow pigments widely found in plants. These pigments typically exist as glycosides, which makes them appear pale and water-soluble. When hydrolyzed by acid, alkali, or enzymes, they become insoluble in water but dissolve in organic solvents. These pigments are dissolved in the cell sap of epidermal and underlying tissues, rather than being membrane-bound. Flavonoids are classified into two groups: **anthocyanins** and **anthoxanthins**.

Anthocyanins:

Anthocyanins are highly water-soluble pigments, ranging in color from red to purple. They are found as glucosides in various parts of plants, and upon hydrolysis, they produce an aglycone residue known as **anthocyanidin**. Anthocyanins are primarily found in the vacuoles of plant cells, where their solubility in water allows them to disperse freely. These pigments are responsible for the vibrant colors of cherries, red apples, berries, grapes, pomegranates, and currants. Additionally, the red color of radish and sweet potato skins, as well as the leaves of red cabbage, is due to anthocyanins. However, in purple eggplant, anthocyanins are insoluble in water.

Betalains:

In some plant families, anthocyanins are absent and replaced by betalains, which include **beta-cyanins** and **beta-xanthins**. These pigments are water-soluble and contain nitrogen in their heterocyclic ring structures, having distinct metabolic pathways for synthesis. The ratio of beta-cyanin to beta-xanthin affects the color of the plant, with higher beta-cyanin levels leading to violet, moderate levels to red, and lower levels to orange. **Betanidin** and **betanin** are the primary pigments in the beta-cyanin group, which is found in beetroot.

Tannins:

Tannins are widely distributed in plants and can be found in varying amounts across species. These complex mixtures of polymeric polyphenols are present throughout the plant, especially in the woody parts, stems, and rootstocks. Tannins can range from colorless to yellow or brown and contribute to astringency, influencing the flavor and body of beverages like tea, coffee, wine, apple cider, and beer. Water-soluble tannins are present in the juices of fruits such as grapes and apples, as well as in brewed tea and coffee. The brewing water's hardness and pH also influence the color and clarity of tea.

Anthoxanthins:

Anthoxanthins are colorless or pale yellow pigments closely related to anthocyanins and are also water-soluble. They are commonly found in the vacuoles of plant cells and are widely distributed in the plant kingdom. Anthoxanthins may be present in complex mixtures and their color can range from white to yellow depending on the pH. These pigments contribute to the color of cauliflower, onions, spinach, and other leafy vegetables, although chlorophyll often masks their color in green leafy vegetables.

Subcategories of Anthoxanthins:

- **Leucoanthoxanthins**: These colorless pigments contribute to the astringency of foods such as apples and olives and play a key role in enzymatic browning in fruits.
- **Catechins**: These pigments are involved in enzymatic browning processes.
- **Quinones**: A yellow pigment called **juglone** is a quinone found in walnuts.
- **Mangiferin**: A yellow pigment belonging to the xanthone group, found in mangoes.

Pigments in Fruits:

Fruits, like vegetables, contain a variety of pigments that contribute to their color:

- **Chlorophyll**: Guava, gooseberry, country apple
- **Carotenoids**: Mango, papaya, orange, watermelon (lycopene), musk melon (beta-carotene), jackfruit, peaches (violoxanthins), tomatoes, pink grapes (lycopene, beta-carotene), pineapple (violoxanthin, beta-carotene)
- **Anthocyanins**: Grapes, blueberries, plums, cherries
- **Anthoxanthins**: Guava, apple, gooseberry, pears, custard apple, banana

This version maintains the information's integrity but restructures and rephrases it for clarity. Let me know if you need any further revisions!

8.5 FLAVOUR CONSTITUENTS:

Flavor Constituents of Fruits and Vegetables:

The flavor of fruits and vegetables is a key factor in their acceptance as part of the diet. The overall flavor impression is the result of both the taste perceived by the taste buds and the

aromatic compounds detected by the olfactory receptors in the nose. In the case of fruits and vegetables, this involves the tasting of sugars, acids, salts, and bitter compounds, while the food is chewed in the mouth.

Taste Components:

- **Sweetness**: Sweetness in fruits and vegetables arises from sugars like glucose, galactose, fructose, ribose, arabinose, and xylose. Glucose, the most abundant of these sugars, may be present in its free form or as phosphate esters and other derivatives.
- **Salts**: All fruits and vegetables contain small amounts of salt, which contributes to their flavor. Certain vegetables, such as kovakka, naturally contain higher amounts of salt, so they require less added salt during cooking.
- **Astringency**: Some fruits and vegetables, such as apples, possess an astringent taste, which is attributed to phenolic compounds or tannins. These compounds give a drying sensation in the mouth.

Sulfur Compounds and Strong Flavors:

Two vegetable groups are particularly known for their strong flavors due to the presence of sulfur-containing compounds:

1) **Allium Family**: This includes onions, garlic, and leeks. These vegetables contain sulfur compounds like cysteine sulphoxide derivatives, such as **allicin** and **allin**. When the plant cells are damaged (e.g., during chopping), the enzyme **alliinase** is released, catalyzing the formation of volatile sulfur compounds, including **thio sulphanates** and **thiols**, which contribute to the pungent, eye-irritating effects of onions.
2) **Cruciferae Family**: Vegetables such as Brussels sprouts, broccoli, cabbage, cauliflower, turnips, kale, and mustard are also noted for their strong flavors, largely due to sulfur compounds. These flavors are more pronounced when the vegetables are overcooked. Cruciferous vegetables tend to have milder flavors when raw but develop stronger tastes upon improper cooking.

Onions and garlic, in particular, release sulfur compounds that cause the typical biting and burning sensations on the tongue when cut or peeled. These sulfur compounds are responsible for the "lacrymator" effect, which causes eye irritation.

Volatile Flavor Compounds:

Fruits and vegetables contain a variety of volatile compounds that contribute to their distinctive flavors. These include:

- **Esters**: Contributing to fruity and sweet aromas.
- **Aldehydes**: Imparting sharp or pungent flavors.
- **Acids**: Adding sourness or tanginess.

- **Alcohols**: Providing sweet, floral, or fruity notes.
- **Ketones and Ethers**: Contributing subtle nuances to the overall aroma profile.

For example, the characteristic flavor of jackfruit is attributed to a mixture of 13 esters (mainly 3-methyl butanoates), 9 alcohols, 5 aldehydes, 5 acids, and traces of unusual compounds like **2-acetyl 1-pyrroline**, which gives it a unique aroma.

Other Flavor Influences:

- **Sugars, Tannins, and Minerals**: In addition to volatile compounds, sugars, tannins, acids, and mineral salts all contribute to the overall flavor of fruits and vegetables.
- **Essential Oils**: Some fruits contain essential oils, which are also important contributors to their flavor profiles.

8.6 EFFECT OF COOKING:

Changes During Cooking:

- **Color, Flavor, and Texture**: Cooking enhances the appearance, taste, and texture of vegetables, making them more palatable. It also improves digestibility by softening fiber, gelatinizing starch, and coagulating proteins.
- **Microbial Safety**: Cooking kills microorganisms, ensuring food safety.

Water Content:

- Cooking methods like boiling or steaming may cause water absorption in vegetables. In contrast, baking removes water. Excess water absorption leads to sogginess, while leafy vegetables like spinach wilt due to cell wall permeability, losing water and turgor.

Cellulose and Pectic Substances:

- **Cellulose, Hemicellulose, and Lignin**: These fibrous substances soften with cooking. Younger plants have thinner cell walls, mostly made of cellulose, while older plants contain more hemicellulose and lignin, which remain tough during cooking.
- **Pectic Substances**: Pectin in plant cell walls changes during cooking, becoming more soluble, which facilitates cell separation and contributes to tenderness. The addition of calcium salts (e.g., calcium chloride) can prevent softening and increase firmness, used in canned vegetables like tomatoes.

Other Carbohydrates:

- **Starch**: During cooking, starch granules absorb water and gelatinize, leading to a viscous, pasty suspension. This causes the texture to become firm, but excessive starch release can result in pastiness (e.g., mashed potatoes). Dextrinization occurs when starches are heated, particularly when potatoes are fried.

- **Sugars**: Starch in potatoes may convert into sugars upon heating. This contributes to browning during frying (caramelization). Waxier potatoes brown quickly due to higher sugar content, while mealy potatoes cook more evenly.

Proteins:

- Proteins in vegetables coagulate partially or completely during cooking, affecting texture and structure.

Nutrient Loss During Cooking:

- **Mechanical Losses**: Nutrients, especially those under the skin of vegetables, can be lost during peeling (e.g., carrots).
- **Solvent Action of Water**: Water-soluble vitamins (e.g., Vitamin C, B-vitamins) may leach into the cooking water. To reduce nutrient loss, methods like steaming, pressure cooking, or cooking with the skin on can help preserve nutrients. The water used for cooking can also be reused.
- **Oxidation and Chemical Decomposition**: Vitamin C is highly susceptible to oxidation, particularly when cell structures are damaged during chopping. The presence of oxygen, heat, or an alkaline medium accelerates nutrient degradation. Vitamin A is also affected by heat and dehydration.

Effects on Sulfur-Containing Vegetables:

- **Cruciferae Family**: Vegetables like cabbage, broccoli, and cauliflower contain sulfur compounds like **isothiocyanates**. When cooked, these compounds can break down into volatile sulfur compounds like **hydrogen sulfide** and **dimethyl sulfide**, contributing to the strong odor.
- **Allium Vegetables**: Garlic and onions contain **alliin**, which, when crushed, forms the pungent compound **diallyl thiosulphinate**. This unstable compound converts into **diallyl sulfide**, responsible for garlic's characteristic aroma. In onions, the enzyme **alliinase** also contributes to the eye-irritating sulfur compound formation.

Key Takeaways:

- Cooking improves the palatability and digestibility of vegetables but can lead to nutrient losses, especially water-soluble vitamins.
- Methods like steaming and pressure cooking can reduce nutrient loss, while the addition of calcium salts can enhance firmness.
- Sulfur compounds in certain vegetables, such as onions and garlic, contribute to strong flavors and odors when cooked.

8.7 BROWNING:

Browning occurs in fruits and vegetables through two primary mechanisms: **enzymatic browning** and **non-enzymatic browning**.

1. Enzymatic Browning:

- **Cause**: This occurs when tissues of fruits like apples, bananas, potatoes, and brinjal (eggplant) are cut or injured, exposing the inner tissues to air. The **phenol oxidase** (or polyphenol oxidase) enzyme present in the tissues reacts with phenolic compounds in the plant, such as **tyrosine**, **chlorogenic acid**, and **catechins**.
- **Process**: Upon exposure to oxygen, the enzyme catalyzes the oxidation of phenols to form **orthoquinones**, which quickly polymerize into brown pigments, leading to the characteristic browning.
- **Enzyme Activity**: The enzyme **phenolase** (also called polyphenol oxidase, tyrosinase, or catecholase) is most active in a pH range of **5 to 7**. When plant tissues are cut or bruised, the enzyme is released from the vacuoles and acts on the polyphenols, causing the discoloration.

2. Non-Enzymatic Browning:

- **Cause**: This type of browning does not involve enzymes but occurs through **chemical reactions** between certain substances present in the food.
- **Ascorbic Acid Reaction**: **Ascorbic acid** (Vitamin C) plays a role in non-enzymatic browning, particularly in fruit juices, concentrates, and canned vegetables. When ascorbic acid is exposed to heat or interacts with amino acids, it can lead to the formation of **brown pigments**. In the decomposition of ascorbic acid or **dehydroascorbic acid**, highly reactive compounds like **furfural** and **osone** are formed, contributing to the browning.
- **Examples**:
    - **Lime Juice**: When subjected to heat, such as in evaporation, lime juice undergoes non-enzymatic browning, which also impacts flavor and limits shelf life. However, using **vacuum evaporation** at lower temperatures (30-50°C) can help prevent browning.
    - **Tamarind Pulp**: Tamarind contains phenolic compounds, including **proanthocyanidins**, and ascorbic acid. These compounds are prone to oxidation, causing darkening. The browning process accelerates with higher temperatures, and **refrigeration** can help slow down this oxidation.
    - **Ketchup and Wine**: In processed products like ketchup and wine, **non-enzymatic browning** occurs through the **Maillard reaction**, a chemical reaction between **reducing sugars** and **amino acids**, leading to the formation of brown pigments and flavors.

8.8 SUMMARY:

Fruits and vegetables are essential components of a healthy diet, offering numerous health benefits due to their high water content, rich nutrient profile, and diverse range of flavors, textures, and colors.

General Composition:

- **Water Content**: Fruits and vegetables are primarily composed of water, often exceeding 80% in many varieties.
- **Low Protein and Fat**: They have minimal protein and fat content, making them light and digestible.
- **Carbohydrates**: They are rich in carbohydrates, including **dietary fiber**, which is vital for digestive health.
- **Vitamins and Minerals**: Fruits and vegetables are packed with essential vitamins (like Vitamin C, Vitamin A, folate) and minerals (such as potassium, magnesium, and calcium), crucial for overall health.
- **Phytochemicals**: They contain various phytochemicals like **flavonoids**, **carotenoids**, and **glucosinolates**, which have antioxidant and anti-inflammatory properties, contributing to disease prevention.

Important Considerations:

Variability in Composition:

- Nutrient levels can vary significantly between different types of fruits and vegetables.
- Factors such as **variety**, **growing conditions**, and **maturity** can influence the composition, meaning the nutrient content can differ even within the same type of fruit or vegetable.

Bioavailability:

- The body's ability to absorb nutrients can be affected by the **cooking methods** and the presence of other food components.
- For example, cooking methods that involve water may cause **water-soluble nutrients** like Vitamin C to leach out, while **fat-soluble vitamins** (like Vitamin A and carotenoids) may be better absorbed when cooked with a small amount of fat.

Health Benefits:

- A regular and diverse intake of fruits and vegetables is linked to a reduced risk of chronic diseases such as **heart disease**, **cancer**, and **diabetes**, due to their nutrient density and antioxidant properties.

Cooking Effects on Fruits and Vegetables:

Cooking vegetables and fruits can enhance **color**, **flavor**, and **texture**, improving their overall palatability and digestibility. Key changes include:

- **Softening of fiber**: Cooking softens the fiber in vegetables, making them easier to chew and digest.
- **Gelatinization of starch**: Heat causes starch granules to absorb water and swell, contributing to the soft texture of cooked vegetables like potatoes.
- **Coagulation of protein**: Heat causes proteins to coagulate, changing their texture and making them easier to digest.
- **Destruction of microorganisms**: Cooking also helps eliminate harmful microorganisms, making fruits and vegetables safe to eat.

Pigments and Color in Fruits and Vegetables:

The pigments found in fruits and vegetables play a key role in their color and visual appeal. These pigments are located in the **plastids** (such as **chloroplasts** and **chromoplasts**) within the cells:

- **Chlorophyll**: The green pigment, which is crucial for photosynthesis, is **insoluble in water**. It can become dull or change color when exposed to heat or acid.
- **Carotenoids**: These **fat-soluble pigments** give fruits and vegetables their orange, red, and yellow hues. Carotenoids are the most stable pigments and are often retained during cooking.
- **Flavonoids**: These **water-soluble pigments** include:
    - **Anthocyanins**: Found in fruits like blueberries and grapes, producing colors ranging from red to purple to blue.
    - **Anthoxanthins**: Found in cauliflower and other white or pale vegetables, they are colorless or pale yellow.
    - **Phenolic Compounds**: They can produce clear to brown pigments, with an intense color in the presence of acid (e.g., in red cabbage).

8.9 TECHNICAL TERMS:

β – carotene, Palatability, , gelatinization, dextrinization, caramalization, Chlorophyll, β- carotenoid, anthocyanidin, Leucoanthoxanthins, Catechins, Quinone, juglone, pelargonidin, cyanidine, delphinidin, pheophytin.

8.10 SELF ASSESSMENT QUESTIONS:

1) Write about classification and composition of vegetables?
2) Discuss about classification and composition of fruits?
3) Classify the pigments present in vegetables and fruits?
4) What are the various changes that occur during cooking of vegetables?
5) What are the flavour components present in fruits and vegetables?
6) Explain the effect of cooking on sulphur containing vegetables?
7) Discus about effect of cooking on pigments?

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LESSON-9

MILK: COMPOSITION, KINDS OF MILK, FUNCTIONAL PROPERTIES OF MILK

OBJECTIVES:

After going through this lesson students will understand:

- To understand the nutritional and chemical makeup of milk and how it contributes to human health and various food products.
- To identify and understand the different types of milk and their uses in food products.
- To investigate the various roles of milk in the food industry, suchasan ingredient in baked goods, beverages, and processed foods.

STRUCTURE:

9.1 INTRODUCTION:

Milk is the one food for which there seems to be no adequate substitute. All mammals produce milk after the birth of the young ones and man has used the milk of many animals as his food. The cow is the most important of all these animals as supplier of food

but buffalo or goat milk is also used. Milk contains many nutrients including calcium, protein as well as lactose and saturated fat Immune factors and immune- modulating components in milk contribute to Early-lactation milk, which is called colostrum, contains antibodies and immune-modulating components that strengthen the immune system against many diseases.

They are processed in a sense so as to be sold and can be used by households. Raw milk is rich in essential vitamins and minerals. Cow's milk is the most widely use milk in the world and it is also used for other dairy products such as cheese, gelato, ice cream and yogurt. Milk is a complex mixture of lipids, carbohydrates, proteins and many other organic compounds and inorganic salts dissolved or dispersed in water. The most variable component of milk is the fat followed by proteins.

9.2 COMPOSITION OF MILK:

Milk is a complex mixture of liquids, carbohydrates, proteins and many other organic compounds and inorganic salts dissolved or dispersed in water. The most variable components of milk is fat followed by protein. Milk is a compound liquid which contains fat in emulsion form, protein in colloidal state and lactose as true solution.

The composition of milk varies with the species, breed, diet, lactational period and interval between milking. There is individual variation also.

9.2.1 Fat:

Buffalo's milk contain 6.5 per cent fat. Cow's milk contains 4.1 per cent fat. Milk fat or butter fat is of great economical and nutritive value. The flavour of milk is due to milk fast. Milk is a true emulsion of oil-in-water. The fat globules are stabilised by a surrounding embrane composed of proteins, phospholipids and cholesterol. Fat globules are visible under a microscope. Each globule of fat is surrounded by a thin layer which is composed of a lipid-protein complex and a small amount of carbohydrate. The lipid portion includes both phospholipids and triglycerides.

Fat globules vary widely in size from 2 to 10 μm (micro meters) and in number 3 x 10^9 per ml. The larger fat granules come to the surface of milk more quickly due to low specific gravity and this can be observed in the transportation of milk.

Milk fat is a mixture of serval different glycerides. They contain about 64 per cent fatty acids ranging from 4 to 26 carbon atoms. Milk contains considerable amount of short chain fatty acids which gave the characteristics flavour and off flavour. Due to their low melting point -10 to -12∘C, they give soft solid consistency to butter. Saturated fatty acids account for butyric and caproic acid 62 per cent and unsaturated 37 per cent. Of the unsaturated fatty acids, 3.8 per cent constitute polyunsaturated fatty acids. Other lipid materials present in milk are phospholipids, sterols, free fatty acids, carotenoids and fat- soluble vitamins.

Carotenes are responsible for the yellow colour of milk fat. Gerber test is used to know the percentage of fat present in food. Milk fat absorbs volatile odour very readily. Milk, butter and cream should not be exposed to strong odours.

9.2.2 Proteins:

Casein: Casein constitutes 80 per cent of the total nitrogen in milk. It is precipitated on the acidification of milk to pH 4.6 at 20^0C. The remaining whey protein constitutes lactoglobulin and lactalbumin. Milk protein contains proteoses, peptones and milk enzymes.

Casein is classified as a phosphoprotein because of the phosphoric acid that is contained in its molecular structure. At the normal acidity of fresh milk (about pH 6.6), casein is largely combined through the phosphoric acid part of its structure with calcium caseinate, Hence, casein occurs in milk as a colloidal protein calcium phosphate complex.

Casein is also a glycoprotein. Glutamic acid is the predominant one in casein. Proline, aspartic, leucine, lysine and valine are also present. Casein is a good source of essential amino acids. Casein contains 8.2 percent calcium and 5.7 per cent carbohydrates.

Casein can also be separated from milk by the addition of rennin, an enzyme secreted by the young calves.

Whey proteins: Whey proteins are made up of a α-lactalbumin and β-lactoglobulin, serum albumin, the immunoglobulins, enzymes and proteose-peptones, β-lactoglobulin accounts for about 50 per cent of total whey proteins. These are not precipitated by acid or rennin, they can be coagulated by heat. Whey also contains small amounts of lactoferrin and serum transferrin. By a process involving ultra filtration, whey proteins concentrate is produced. Whey protein isolates are also produced. It can be given in lactose intolerance.

9.2.3 Carbohydrate :

Milk contains 4-5 per cent carbohydrates. The chief carbohydrates present in milk is lactose, a disaccharide, although trace amounts of glucose, galactose and other sugars are also present. Lactose gives on hydrolysis glucose and galactose. Lactose has only one sixth the sweetness of sucrose and one third-one fourth of its solubility in water. When milk is heated, lactose reacts with protein and develops a brown colour, the development of brown colour is due to nonenzymatic browning. It is called Maillard reaction. The acid fermentation is used in making butter, cheese and curd.

9.2.4 Minerals:

Chlorides, phosphates, citrates, and bicarbonates of sodium, potassium, calcium, and magnesium, are present. These salts influence the condition and stability of the proteins, especially the casein fraction. Copper and iron are important in the development of off flavors in milk and milk products. In addition to this, milk contains trace elements like zinc, aluminum, molybdenum and iodine.

9.2.5 Enzymes:

The enzymes found in milk can originate from the mammary gland as any other native constituent or may be released by contaminating bacteria. Alkaline phosphatase exists as

lipoprotein and is distributed between the lipid and aqueous phases. This enzyme is inactivated by normal pasteurization procedures and its activity is tested to determine the effectiveness of pasteurization. Morethan one type of lipase occurs in milk. The release of membrane material from the fat globule predisposes the fat lipolytic attack by plasmalipase. Milk lipase is responsible for the development of rancid flavors in milk. Bacterial lipase is very resistant to heat and can cause serious quality defects. Lipases may be important in the development of desirable flavors in some cheeses. Xanthin oxidase occurs in the fat globule membrane. It is a conjugated protein complexed with FAD, iron and molybdenum. The enzyme degradation of FAD gives FMN and riboflavin. The riboflavin content of milk may thus be due to xanthin oxidase.

Xanthine oxidase enzyme concentration averages 160 mg/l. Xanthine oxidase can catalyze the oxidation of aldehydes which are some of the aroma constituents infermented dairy products. The enzyme is not destroyed by pasteurization. Catalase is an enzyme that promotes the decomposition of hydrogen peroxide to water and molecular oxygen. Fresh milk from a healthy cow contains insignificant amounts of catalase as compared to the milk from diseased udders. Lactoperoxidase catalyzes the transfer of oxygen from peroxides, especially hydrogen peroxide to other readily oxidizable substance.

9.2.6 Color:

White color of milk is caused by the reflection of light by the colloidally dispersed casein, Calcium and phosphorus. Yellowish color of milk is due to the presence of carotene and riboflavin. The fat-soluble carotenes are found in the milk fat; the riboflavin is water soluble which can be visible clearly in whey water.

The white color of milk is one of its most distinctive properties. It has the same scientific reason as the color white but its chemical compounds too contribute in making it white.

9.2.7 Flavor and Aroma:

To most of the people, normal milk tastes slightly sweet with its mild aromatic flavor. The sweet taste comes from the flavor and aroma principally from milk sugar and butter fat. Milk is slightly sweet because of its lactose content. Flavor sensation in mouth is due to milk fat in the serum or watery portion of milk and the colloidal structure of the protein and some the salts such as calcium phosphate. The slight aroma of fresh milk is produced by a number low molecular weight compounds such as acetone, acetaldehyde, dimethyl sulfide and short chain fatty acids. Some of the volatile compounds to the flavor of milk is unique to the fat portion of milk. Boiling changes the flavor of fresh milk more than pasteurization.

Many chemicals off rancid or oxidized flavors. Some of the polyunsaturated fatty acids are particularly susceptible to unto oxidation in the presence of oxygen and unpleasant flavor substances are produced. Anything that alters the membrane and permits contact of the lipases with the fat will promote rancidity and off flavor, are also produced when milk is exposed to light. In this reaction tryptophan and riboflavin may be involved and their content decreases when the off-flavor develops.

9.3 KINDS OF MILK:

9.3.1 Non-Fermented Milk Products:

1) Skim Milk:

Skim milk is also known as Fat-Free or Non-Fat Milk. Skim milk is a type of market milk that has had almost all of its fat removed, containing less than 0.5% milk fat. It is also known as fat-free milk or non-fat milk in some regions. Despite the removal of fat, it retains the same protein, calcium, and other essential nutrients as whole milk. The fat is removed using a centrifugation process. It is then pasteurized (heated to kill bacteria) and homogenized (to ensure a uniform texture).In many countries, vitamins A and D are added back to compensate for nutrient loss. Skim milk has a thinner, more watery texture compared to whole milk due to the absence of fat. Common in weight-loss and low-fat diets.

2) Evaporated Milk:

Evaporated milk is a form of concentrated milk where about 60% of the water content has been removed through a heating process. It has a thicker consistency than regular milk and a slightly caramelized flavor due to the heating process. It is commonly used in cooking, baking, and coffee. Fresh milk is heated under low pressure to remove about 60% of its water. The heating process kills bacteria and caramelizes some of the natural sugars, giving it a slightly golden color and richer taste. The milk is then homogenized to prevent separation and canned for long shelf life. Has a thicker and creamier consistency than regular milk. Slightly sweeter and caramelized flavor due to the heating process. The heating process breaks down some lactose, making it easier to digest for some lactose-sensitive individuals.

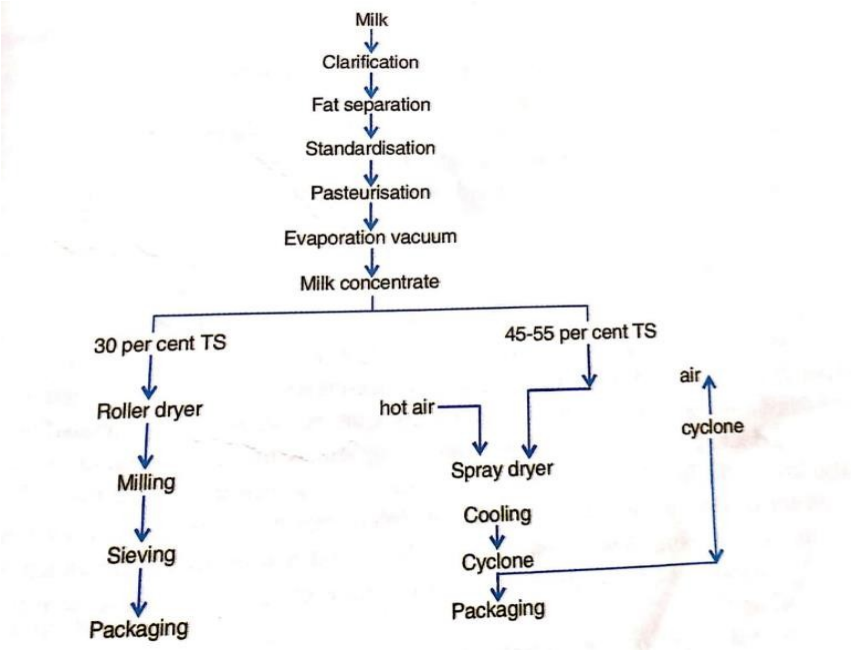

Fig. 9.3.1. Manufacture of Milk Powder

Source: Food Science B. Srilakshmi.

3) Dry Milk (Powdered Milk):

Dry milk, also known as powdered milk, is a dairy product made by removing all moisture from milk through dehydration. This process extends its shelf life significantly and makes it easy to store and transport. It can be reconstituted by mixing it with water or used as an ingredient in various food products. Whole milk powder has a higher calorie and fat content. The production of dry milk involves Pasteurization, Evaporation and Spray Drying or Roller Drying.

- **Types of Dry Milk:**

There are different types of dry milk based on fat content and processing methods:

1) **Whole Milk Powder:** Contains full-fat content (~26-40% fat).
2) **Skim Milk Powder (Non-Fat Dry Milk):** Contains less than 1.5% fat, ideal for low-fat diets.
3) **Instant Dry Milk:** Dissolves more easily in water due to a special processing method.
4) **Sweetened Condensed Milk:** Sweetened condensed milk is a thick, rich, and very sweet dairy product made by removing about 60% of the water from regular milk and adding a large amount of sugar. The sugar acts as a preservative, giving it a long shelf life without refrigeration until opened is very thick and creamy, almost like syrup. It is high in sugar, not suitable for diabetics or those on a low-sugar diet.
5) **Toned Milk:** Toned milk is a type of milk that is made by mixing whole milk with skim milk and water to reduce the fat content while maintaining its nutritional value. It was originally developed in India as a way to increase milk supply and make it more affordable while still providing essential nutrients. It Contains 3.0% fat and 8.5% non-fat solids. Skim milk and water are mixed with whole milk. It is good source of protein and calcium, supporting muscle and bone health. Easier to digest than full-fat milk. It is more affordable than whole milk, making it an economical option.
6) **Double Toned Milk:** Double toned milk is a type of milk that has been processed to reduce its fat content to 1.5% while maintaining a minimum of 9% non-fat solids (SNF). It is made by mixing whole milk with skim milk and water and is a healthier, lower-fat alternative to full-cream or standardized milk. Double toned milk is a great low-fat option for people who want to cut down on fat while still enjoying.
7) **Recombined Milk:** Recombined milk is a type of milk that is made by mixing milk fat (butterfat), non-fat milk solids (skim milk powder), and water in specific proportions to recreate milk with desired fat content. This type of milk is often used in regions where fresh milk supply is limited or expensive. Similar to fresh milk but can have a slightly different mouth feel due to reconstitution. Good source of protein and calcium, essential for strong bones and muscles. It can be stored as dry ingredients and reconstituted as needed. It is available in regions with low fresh milk supply, making it a useful alternative.

8) **Sterilized Milk:** Sterilized milk is milk that has been heat-treated at high temperatures (above 100°C for an extended period) to destroy all bacteria, including spores, making it safe for long-term storage without refrigeration until opened. This process extends shelf life while maintaining the milk's nutritional value. In-Bottle Sterilized Milk, milk is sealed in glass bottles and heated to 110-120°C for 20-30 minutes. It has a slightly caramelized flavor due to the high heat process. It is safe for consumption as it eliminates harmful bacteria and pathogens. It also has a long shelf life.

9) **Ultra-High Temperature (UHT) Milk:** UHT milk, or Ultra-High Temperature milk, is milk that has been heated to 135-150°C for 2-5 seconds to kill all bacteria and spores, allowing it to be stored without refrigeration for 6 months or more in a sealed container. It is also known as long-life milk. Tetra packs are used as a packing material. UHT milk has a cooked flavor due to denaturation of the whey protein Beta-lactoglobulin. Off flavors develop due to chemical and enzymatic activity. The addition of flavorings to milk masks off flavor.

10) **Filled Milk:** Filled milk is a type of milk in which milk fat (butterfat) is replaced with vegetable fat (such as coconut, palm, or soybean oil). It is used as a cheaper alternative to whole milk, especially in regions where dairy fat is expensive or unavailable. In this milk solids (skim milk powder) are mixed with water to create a milk base. And vegetable fat (such as coconut or palm oil) is added to replace dairy fat. Then the mixture is homogenized to ensure even fat distribution and pasteurized. It is an affordable alternative to dairy milk, especially in countries with limited milk production.

11) **Flavored Milk:** Flavored milk is milk that has added flavors, sweeteners, and sometimes color to enhance its taste. Common flavors include chocolate, vanilla, strawberry, coffee, and cardamom. It can be made from whole, toned, skim, or plant-based milk and is often fortified with vitamins and minerals. Flavors, sweeteners, and colors are also added. High in added sugar, which can contribute to weight gain and diabetes if consumed excessively. It is mostly used in milkshakes, smoothies, and ice creams.

Common Flavors of Flavored Milk:

a) Chocolate Milk-Most popular, made with cocoa and sugar.

b) Strawberry Milk-Sweet, fruity taste with pink coloring.

c) Vanilla Milk-Smooth, mild, and aromatic.

d) Coffee Milk-Blended with coffee extract for a rich taste.

e) Mango or Banana Milk-Fruity, tropical flavors.

f) Cardamom or Saffron Milk-Popular in South Asian and Middle Eastern countries.

12) **Colostrum**: The milk from Necole-carved animals has high acidity and rich in protein and carotenoids. It gets coagulated at very low temperatures and the milk is diluted with ordinary milk and steam cooked with jaggery and cardamoms -21 can be cut into pieces.

13) Cream: Milk fat separated from milk by centrifugation is called cream. Creams containing various amount of fat are made to meet different requirements. A mixture of milk and milk fat of 10-12% is called half-and-half. The high percentage of fat helps to give a more stable foam. Cream used for butter making usually contains from 25-40%. Cream is also used in baked products and as well as salad dressings. Cream (18 per cent fat) is pasteurized at 70-75 C for 30 minutes to kill the bacteria. The cream is then inoculated with the controlled culture of lactic acid bacteria to develop the desired acid taste in the finished products.

14) Whey Protein Concentrate: The milk is first coagulated by application of either rennet or acid. Whey is passed through the membranes called ultra filtration technology to concentrate protein to various levels between 20-80%. Bioactive components found in whey are retained and concentrated e.g., cysteine stimulates glutathione system which is a powerful antioxidant. The biological value and fv protein efficiency ratio is high. Whey protein concentrate can be used in cookery and the role in food preparations is given.

9.3.1 Fermented Milk Products:

1) Butter: The fat content of butter is generally about 80% the non-fat components of butter consist of moisture milk Solids not fat and salt it added Most of the butter produced in our country is converted to ghee Butter is made from sweet or sour cream. The Cream is pasteurized at 62.8°C for 30 minutes after which it is immediately. Cooled then a culture of desirable micro-organisms is added. The culture consists of bacteria of two types. Taconiticcitrovorum principally allays the citric of milk-producing volatile acids and products such as diacetyl which gives the disabled flavor and aroma to the butter, the cream is then allowed to ripen at 21.1°c for several hours for the fermentation to take place. The ripened cream or Dahi is next churned. Churning brings about the denaturation, by violent agitation of the fat globule surface, the membrane material is eliminated in butter milk.

2) Cheese: The varieties of cheese are differentiated according to their flavor, body and the texture which in turn depends upon the type of the milk used, manufacturing and processing method adopted, salts and seasoning, added and the type of bacteria and mold species used in the ripening. Cheese is classified as hand or soft depending. On their moisture content and whether they are ripened by bacteria or molds or unripe.

3) Curd: Pasteurized whole milk is bought to a temperature of 31^0c and lactic acid Producing starter culture and required Coloring matter are added. After about 30 minutes to the mildly acidic milk rennin solution, is added, stirred and allowed to set the curd for 30 minutes.

Curd Cutting: The curd is cut into small cubes the removal of whey from small cubes is easy. For different type of cheese, the curd is cut into different sized cubes. Then it is heated to 38°c and held at that temperature for about 45 minutes. During this period, the

curd is stirred to prevent matting. Curd drainage: Heating squeezes out Whey torn the cubes. Heat increases the rate of acid production which makes the curd cubes shrink Whey is drained off and the curd is allowed to mat Cheddaring.

4) Paneer: Unripen cheeseis called paneer. Paneer is made at home by adding curd to boiling milk. When rennet obtained from the stomach of the goat is used as coagulant for cheese making, the cheese is called 'Surti paneer'. This is manufactured more in Surat and Mumbai. Soft cheese known as ordinary paneer is made from buffalo milk by using berries of Whitmanian coagula as the source of a coagulating enzyme for curding the milk.

9.4 FUNCTIONAL PROPERTIES OF MILK:

Milk is a highly versatile food with various functional properties that make it essential in food processing, cooking, and nutrition. These properties influence texture, flavor, stability, and nutritional quality in various food products. Below are the major functional properties of milk:

1) Solubility: Milk contains proteins (casein and whey), lactose, and minerals, which must remain evenly dispersed in liquid. Solubility affects smoothness and stability in dairy products and beverages. Ensures even dispersion in drinks like coffee, tea, and milk shakes. Prevents graininess in milk powders when reconstituted. Helps in yogurt and cheese making by controlling curd formation.

2. Emulsification: Milk acts as a natural emulsion because it contains milk fat dispersed in water with the help of proteins and phospholipids. This helps in stabilizing fat and water mixtures in dairy and non-dairy products. Essential for butter, cream, and ice cream production. Helps in the smooth texture of cheese, sauces, and dressings. Prevents separation of fat in flavored and UHT milk.

3. Foaming & Aeration: Milk proteins (especially whey and casein) help trap air and moisture, leading to foam formation in whipped dairy products. Essential for cappuccino foam, whipped cream, and milk froth. Helps in ice cream structure, making it light and airy. Improves texture in baked goods like cakes and souffles.

4. Coagulation & Gel Formation: Milk proteins (mainly casein) can coagulate (curdle) when exposed to acids, heat, or enzymes, forming a gel-like structure. Cheese production: Rennet (enzyme) causes milk to coagulate into curds. Yogurt making: Lactic acid bacteria ferment milk, making it thick. Custards & Puddings: Milk proteins form a stable gel with heat.

5. Water-Binding (Hydration Ability): Milk proteins and lactose absorb and retain water, which affects moisture retention in food products. Prevents drying out of baked goods like bread and cakes. Improves creaminess in dairy desserts. Enhances texture in processed meats and soups.

6. **Browning & Caramelization (Maillard Reaction):** Milk contains lactose (milk sugar) and proteins, which react under heat to form golden brown colors and rich flavors. Gives baked goods (cakes, bread) a golden crust. Enhances the color and taste of evaporated and condensed milk. Used in toffee, caramel, and confectionery.

7. **Flavor Enhancement:** Milk contributes to sweet, creamy, and slightly salty flavors due to its fat, proteins, and lactose content. Adds richness to sauces, soups, and dairy-based desserts. Enhances the smooth taste of chocolate, coffee, and tea. Used in cheese and butter production for distinct flavors.

8. **Heat Stability:** Milk proteins remain stable under moderate heat but may denature (break down) at high temperatures. The fat also contributes to heat resistance in some dairy products. Prevents curdling in heat-treated milk (UHT milk, sterilized milk). Important for milk-based sauces and soups. Ensures even cooking in dairy-based custards.

9. **Crystallization (Lactose Crystallization)**: Lactose (milk sugar) can crystallize under low moisture conditions, affecting texture and stability. Affects texture in sweetened condensed milk. Important in ice cream production to prevent grainy textures. Used in dried milk powders to maintain smoothness.

10. **Viscosity & Thickness:** Milk proteins, fats, and sugars contribute to thickness and mouthfeel, which affects liquid and semi-solid dairy products. Gives creaminess to yogurt, custards, and milkshakes. Helps in stabilizing sauces and gravies. Used in ice cream production for a smoother texture.

9.5 CONCLUSION:

Milk products contribute the nutritive value to the diet. Milk is a complex and versatile food that offers a wide range of nutritional benefits and culinary applications. With various types of milk, fermented and non-fermented milk products, The chief carbohydrate present in milk is lactose or milk sugar is a disaccharide, although trace amounts of glucose and galactose there's something for everyone to enjoy and appreciate.

9.6 SUMMARY:

Milk products contribute the nutritive value to the diet. The chief carbohydrate present in milk is lactose or milk sugar is a disaccharide, although trace amounts of glucose and galactose and other sugars or present, physical properties of milk enhance the quality of milk when the pasteurization or boiling techniques are followed well.

9.7 TECHNICAL TERMS:

Flocculation, Pasteurization, Clarification, Homogenization.

9.8 SELF ASSESSMENT QUESTIONS:

1) Write short notes on proteins present in milk.
2) Discuss the factors effecting in handling milk and milk products.
3) Describe the composition of milk.

9.9 REFERENCES:

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Dr. Ch. Manjula

LESSON-10

EGG: STRUCTURE, GRADING, QUALITY AND FUNCTIONAL PROPERTIES OF EGGS

OBJECTIVES:

After going through this lesson students will understand:

- To categorize eggs based on quality standards to ensure consistency in the market and safe consumption.
- To assess the freshness and overall quality of eggs based on their appearance, shell condition, and functionality.
- To understand the nutritional and chemical components of an egg.
- To explore how eggs contribute to the texture, flavour, and stability in various food products.

STRUCTURE:

10.1 INTRODUCTION:

India is one of the largest egg producers in the world. Although eggs of all birds may beeaten, the egg of chicken is used more often than any other. The natural function of an egg is to provide for the development of the chick. It's whole structure and composition are designed to full fill this natural purpose.

An egg an organic vessel grown by an animal to carry a possibly fertilized egg cell (a zygote) and to incubate from it an embryo within the egg until the embryo has become an animal fetus that can survive on its own, at which point the animal hatches. Most lay eggs although some, such as scorpions, do not reptile eggs, bird eggs, and monotremes eggs are layout of

water and are surrounded by a protective shell, either flexible or inflexible eggs laid on land or in nests are usually kept within the embryo grows. When the embryo is adequately developed it hatches breaks out of the egg shell. Some embryos have a temporary egg tooth they use to crack or break the egg shell.

Some eggs laid by reptiles and most fish, amphibians, insects and other invertebrates can be even smaller.

Reproductive structures similar to the egg in other kingdoms are termed “spores” in spermatocytes “seeds” or in gametophytes “egg cells”.

10.2 STRUCTURE OF EGG:

An egg has a complex structure designed to protect and nourish the developing embryo (if fertilized). It consists of several distinct parts, each with specific functions.

1. Egg Shell:

Mainly composed of calcium carbonate ($CaCO_3$) with small amounts of protein and minerals.

Structure:

- Cuticle: A thin outer layer that prevents bacterial entry and reduces moisture loss.
- Spongy (Calcareous) Layer: The main bulk of the shell, providing strength.
- Mammillary Layer: The innermost part, helping in calcium deposition.
- Pores: Tiny openings (~7,000–17,000) that allow gas exchange.

Functions:

- Protects the egg from physical damage and microorganisms.
- Allows the exchange of gases (oxygen and carbon dioxide).
- Controls moisture loss.

2. Shell Membranes:

It has two thin layers. They are Inner and Outer Shell Membranes. Which are composed of keratin-like proteins that are located just beneath the shell. Both them embranes are porous Composed of fibers. The outer membrane which is thicker (48um) than the inner one (22um) is firmly attached to the shell. The outer membrane has six layers of fiber, whereas, the inner one has 3 layers. The membranes are composed of polysaccharide.

Functions:

- Act as a barrier against bacterial invasion.
- Help in regulating moisture and gas exchange.

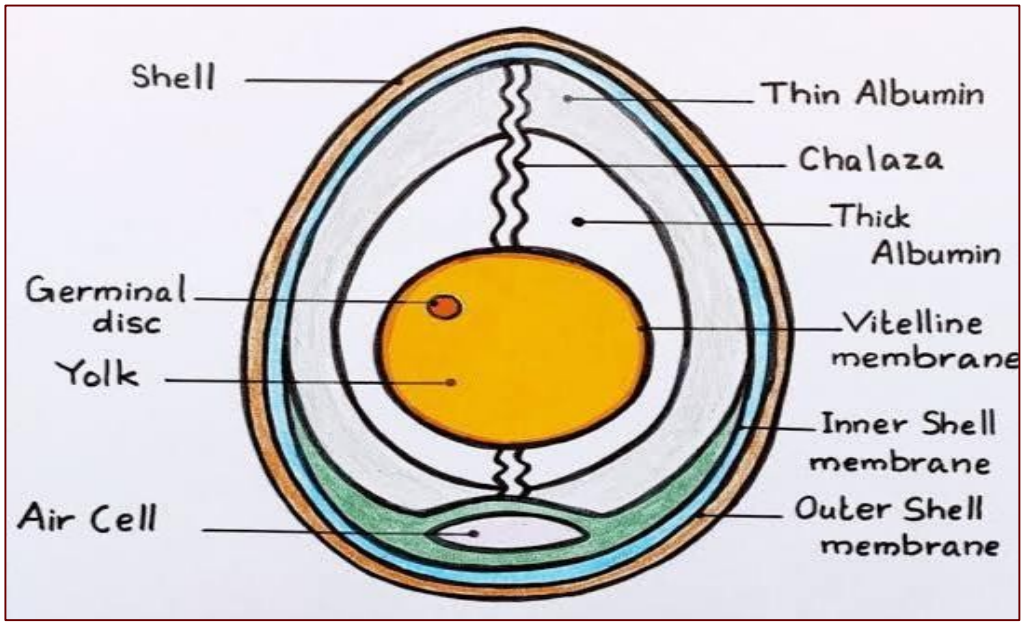

Fig. 10.2.1 Structure of Egg

3. Air Cell:

It is located at the wider end of the egg, between the inner and outer shell membranes. Eggs contain little or no air cells when they are laid. After laid because of the lower temperature of the outer Surroundings of the egg then when it was in the hen's body, there is Contraction of the inner contents of the Egg. This results in a small air cell formation b/w the shell usually at the large end of the egg.

Functions:

- Provides an initial oxygen supply for the developing embryo.
- Grows larger as the egg ages due to moisture and gas exchange.

4. Albumen (Egg White):

A clear, protein-rich substance surrounding the yolk is known as albumin, it is composed of four layers:

1) Outer thin albumen: Watery and closest to the shell.
2) Thick albumen (Dense Albumen): High in protein, surrounds the yolk.
3) Inner thin albumen: Another watery layer next to the yolk.
4) Chalaziferous layer: The innermost part, forming the chalazae.

Functions:

- Provides proteins, water, and cushioning for the embryo.
- Contains enzymes (lysozyme) that protect against bacteria.
- Helps maintain the egg's structure.

Egg White Proteins:

Different types of proteins are present in Egg white. They are

- Ovalbumin
- Conalbumin
- Ovomucoid
- Lysozyme
- Avidin
- Ovomucin
- Ovoglobulin
- Ovoinhibitor

5. Chalazae:

Twisted, rope-like strands of protein (mucin fibers) attached to the yolk is chalazae. It is found on opposite poles of the yolk.

Functions:

- Keeps the yolk centered in the egg.
- Act as a shock absorber, preventing damage to the yolk.

6. Yolk:

A yellow, nutrient-rich mass at the egg's center is called as yolk, which is surrounded by the vitelline membrane, which keeps it intact. Yolk contains Proteins like phosvitin, Fats, Vitamins (A, D, E, K, B-complex) and Minerals like iron, phosphorus, etc.

Functions:

- Provides essential nutrients for embryonic development.
- Supplies energy in the form of fats.

Egg Yolk Proteins:

Egg yolk contains major proteins. They are

- Lipoproteins
- Lipovitellins
- Phosvitin
- Livetin
- Low-Density Lipoprotein

7. Germinal Disc:

Germinal disc is a small white spot on the yolk. If fertilized, it develops into the embryo.

Functions:

- The site of fertilization.
- In fertilized eggs, it initiates embryonic development.

8. Vitelline Membrane:

A transparent membrane enclosing the yolk which keeps the yolk intact and prevents it from mixing with the albumen.

Functions:

- Protects the yolk.
- Maintains the structural integrity of the yolk.

10.3 QUALITY OF EGGS:

Egg quality is assessed based on physical, chemical, and microbiological properties.

1. External Quality (Shell Quality):

The external quality of eggs refers to the appearance, cleanliness, and shell integrity, which are essential for consumer acceptance and food safety.

- Shell Cleanliness: Clean, unstained eggs are of higher quality. Dirty eggs indicate contamination risks.
- Shell Strength & Texture: A good egg has a smooth, strong shell without cracks. Weak shells may be due to calcium deficiency or hen age.
- Shell Thickness: Thicker shells provide better protection against microbial invasion.
- Egg Shape & Size: Normal oval-shaped eggs with a slightly pointed end are ideal. Abnormally shaped eggs may indicate nutritional deficiencies or hen stress.

2. Internal Quality (Egg Content Quality):

Internal quality determines an egg's freshness, nutritional value, and suitability for processing.

- **Albumen (Egg White):**
  - High-quality eggs have thick, firm albumen that holds its shape when cracked.
  - Older eggs have watery, thin albumen, which affects food texture in baking and cooking.

- **Yolk :**
  - Fresh eggs: The yolk is round, firm, and well-centered.
  - Older eggs: The yolk spreads and flattens due to a weakened vitelline membrane.
  - Yolk Color: Dependent on hen diet. A deep yellow or orange yolk indicates high carotenoid content, while pale yolks may suggest nutrient deficiencies.
- **Air Cell Size :**
  - A small air cell (<1/8 inch) indicates a fresh egg.
  - As eggs age, moisture and CO_2 escape, increasing air cell size and reducing quality.
- **Egg Odor & Taste :**
  - Fresh eggs have no off-smell.
  - Spoiled eggs develop a sulfuric (rotten) odor due to bacterial contamination.

10.3.1 Factors Affecting Quality of Egg:

1) Hen's Diet

- High carotenoid feed → Darker yolk.
- Poor nutrition → Thin shells, pale yolks.

2) Hen's Age

- Young hens lay smaller, higher-quality eggs.
- Older hens lay larger eggs with thinner shells and weaker albumen.

3) Storage Conditions

- Refrigeration (0-5°C) preserves freshness.
- Heat speeds up moisture loss and bacterial growth.

4) Egg Handling & Processing

- Rough handling causes cracks → higher risk of microbial contamination.
- Industrial eggs undergo washing, oiling, and pasteurization to extend shelf life.

10.4 EVALUATION OF EGG:

1) Physical Tests for Egg Quality

a) Haugh Unit Test (Albumen Quality):

It measures the thickness and firmness of the egg white.

Method:

- Weigh the egg.
- Break it onto a flat surface.
- Measure the albumen height using a micrometer.
- Calculate the Haugh Unit (HU):

  HU = 100 \times \log (H - 1.7W^{0.37} + 7.6)

  - *W* = egg weight (g)

Interpretation:

- ≥ 72 = Excellent quality
- 60-71 = Good quality
- < 60 = Poor quality

b) Yolk Index Test (Yolk Quality):

It measures the yolk roundness and firmness.

Method:

- Break the egg and place the yolk on a flat surface.
- Measure the yolk height (YH) and yolk diameter (YD).
- Calculate the Yolk Index (YI):

  YI = \frac{Yolk\ Height}{Yolk\ Diameter}

Interpretation:

- ≥ 0.38 = Fresh egg
- < 0.38 = Older egg

c) Candling Test (Air Cell & Internal Defects):

It measures the air cell size, yolk position, and internal defects.

Method:

- Place the egg in front of a bright light (candling lamp).

Observe:

Small air cell (<1/8 inch) = Fresh egg.

Enlarged air cell (>3/16 inch) = Older egg.

Blood spots/meat spots = Poor quality.

d) Water Float Test (Freshness Test):

It measures egg age based on air cell expansion.

Method:

- Place the egg in water.

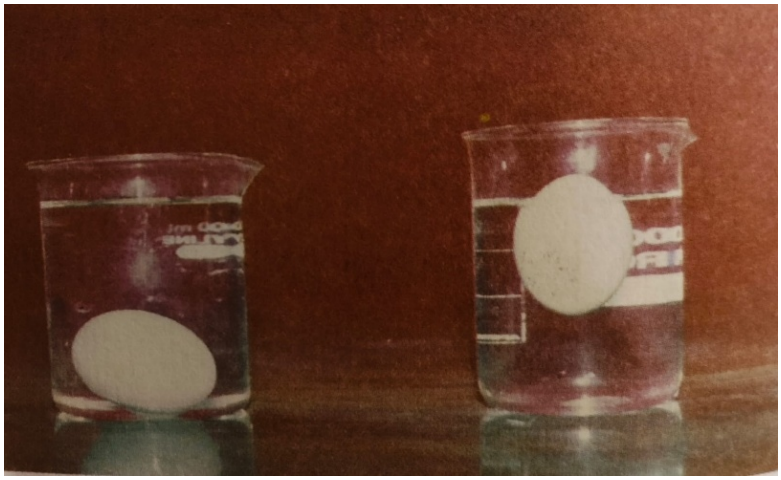

Fig. 10.4.1 Floating Test to Evaluate Egg Quality

Source: Food Science, B. Srilakshmi

- **Observe:**

Sinks and lies flat = Very fresh.

Tilts upward slightly = 1–2 weeks old.

Floats = Old egg (stale).

2) Chemical Tests for Egg Quality:

a) pH Measurement (Egg Freshness & Spoilage)

It measures changes in albumen and yolk pH over time.

Method:

- Break the egg and separate albumen and yolk.
- Measure pH using a pH meter.

Interpretation:

- Fresh eggs: Albumen pH 7.6–8.2, Yolk pH 6.0.
- Older eggs: Albumen pH >9.0, Yolk pH >6.4 (CO_2 loss increases alkalinity).

3) Microbiological Tests for Egg Quality

a) Bacterial Contamination Test

It Measures the presence of Salmonella, E. coli, and Listeria.

Method:

- Swab eggshell and culture in a nutrient medium.
- Identify bacterial growth.

10.5 GRADING OF EGG:

Egg grading is the classification of eggs based on quality and weight. It ensures freshness, safety, and consistency for consumers and industries. Grading is typically done using physical inspection, candling, weight measurement, and scientific quality tests.

1) **Egg Grading Based on Quality:** Eggs are graded based on shell quality, air cell size, albumen thickness, yolk condition, and defects. The United States Department of Agriculture (USDA) system classifies eggs into three quality grades: Grade AA, Grade A, and Grade B.
   - Grade AA: Highest quality, ideal for poaching, frying, and baking.
   - Grade A: Good quality, commonly used for general cooking.
   - Grade B: Lower quality, mainly used for baking, liquid eggs, or processed egg products
2) **Egg Grading Based on Weight (Size Classification):**

   Extra Large: Greater than or Equal to 60 g

   Large: 53-59 g

   Medium: 45-52 g

   Small: 38-42 g

10.6 FUNCTIONAL PROPERTIES OF EGG:

Eggs are an essential ingredient in many food products due to their versatility and ability to perform a variety of functions in cooking, baking, and food processing. The functional properties of eggs refer to their physical and chemical characteristics that allow them to affect the texture, structure, and overall quality of food. These properties arise from the composition of eggs-particularly their proteins, lipids, and water-and their ability to interact with other ingredients.

1) Emulsification:

The ability to blend immiscible liquids (like oil and water) into a stable mixture is known as Emulsification. Eggs contain lecithin, a natural emulsifier found in the egg yolk. Lecithin helps to reduce the surface tension between fat and water molecules, allowing them to combine and form a stable emulsion.

Uses:

- Mayonnaise: Eggs emulsify oil into vinegar or lemon juice.
- Hollandaise sauce: Egg yolks create a smooth, stable mixture of butter and acidic liquids.
- Salad dressings: Eggs help mix oil and vinegar into a creamy texture.

2) Foaming:

The ability to form stable foams, which is especially important in baking and dessert preparation. Egg whites contain proteins, such as ovalbumin, which unfold and form a network when whipped. These proteins trap air and form foam. The stability of the foam increases as the proteins continue to bond and entrap air.

Uses:

- Meringues: Whipping egg whites creates a light, airy foam that holds its shape when baked.
- Angel food cake: Egg whites contribute to the leavening and texture of the cake by providing air pockets.
- Soufflés: Egg whites help give the souffle its rise and light texture.

3) Binding:

Eggs help bind or hold ingredients together. The proteins in the egg white and yolk coagulate (solidify) when heated, forming a gel-like structure that binds ingredients together.

Uses:

- Meatballs or Meatloaf: Eggs act as a binder, holding the ground meat and other ingredients together.
- Burgers: Eggs help maintain the shape and texture of patties.
- Cakes: Eggs bind the dry ingredients to create a smooth batter.

4) Gelation:

The ability of eggs, especially egg yolks, to form gels when heated and cooled. When egg proteins are heated, they denature and form a network that traps water and other substances, creating a gel. This property is important for making custards, puddings, and certain savory dishes.

Uses:

- Custards: Egg yolks create a smooth, creamy texture in custards by forming a gel when heated.
- Puddings: Eggs help form a thick, gel-like consistency when mixed with other ingredients and heated.
- Quiches: Eggs provide structure and hold the filling together.

5) Leavening:

Eggs contribute to the rising of baked goods by trapping air and expanding during baking. When egg whites are whipped, they trap air. In addition, egg yolks provide structure and moisture. During baking, the air expands due to heat, causing the product to rise. The proteins also set, which helps maintain the rise.

Uses:

- Cakes: Eggs help the batter rise, contributing to a light and fluffy texture.
- Bread: Eggs assist in providing a soft crumb and better volume.
- Pancakes: Eggs help the batter rise, resulting in a fluffy texture.

6) Moisture Retention:

Eggs help retain moisture in food products, keeping them moist and improving their shelf life. Contain water (about 75% of the egg's weight), which contributes to the moisture content of the food. The proteins in eggs help trap and retain moisture during cooking and baking.

Uses:

- Cakes and Muffins: Eggs help prevent these products from becoming dry.
- Meatloafs and Meatballs: Eggs retain moisture, ensuring the product remains tender.
- Breads: Eggs improve texture and prevent the bread from becoming too dry.

7) Color and Appearance:

Eggs contribute color to food, especially in products like baked goods, custards, and pastries. The natural carotenoids (such as lutein and zeaxanthin) in egg yolks give food a golden or yellow hue. The presence of eggs in food can also enhance visual appeal through their shiny surface or rich color.

Uses:

- Pastry Crusts: An egg wash on the surface of baked goods gives a golden, shiny finish.
- Custards and Puddings: Egg yolks contribute to the characteristic yellow color.

8) Clarifying:

Eggs can clarify liquids, such as broths or juices, by removing impurities. Egg whites contain albumin, a protein that can trap particles when heated. These proteins coagulate and form a mesh that captures suspended particles, resulting in a clear liquid.

Uses:

- Broth clarification: Egg whites are often used in the clarification of stock or broth in the process of making consommé.
- Juice clarification: Egg whites help clarify juices and wines.

9) Protein Quality:

Eggs are considered a complete source of protein, containing all the essential amino acids required by the human body. The proteins in eggs, such as ovalbumin (egg white) and livetin (egg yolk), have high biological value. This means they provide all the necessary amino acids for human growth and maintenance.

Uses:

- Protein in breakfast meals: Eggs provide high-quality protein for individuals seeking a healthy meal.
- Baked goods: Eggs provide the necessary protein structure to maintain shape and texture.

10.7 CONCLUSION:

In Conclusion, Egg structure, grading, and functional properties are interconnected aspects crucial to egg quality and utility. The structural integrity of the shell, yolk, and albumen influences grading standards and functional roles such as emulsification, binding, and leavening. Proper grading ensures consumer trust, while understanding functional properties enhances their application in culinary and industrial contexts. Eggs remain a versatile and essential ingredient across diverse uses. Egg Quality and grading are crucial aspects of ensuring consumer, safety and Satisfaction. The grading process, based on factors like size, Shell Integrity, and yolk color, provides a Standardized way to categorize eggs.

10.8 SUMMARY:

Eggs are versatile ingredients in cooking, playing key roles as binding, emulsifying, and thickening agents. The egg white, when beaten, forms foam that trap air, making it essential in recipes like meringues or souffles. The proteins in the egg white unfold and then reattach, creating a stable structure that holds air, resulting in volume and lightness. As a binding agent, eggs help hold ingredients together in dishes like meatballs or casseroles. As an emulsifier, the lecithin in egg yolks allows fats and water-based liquids to combine smoothly, making mayonnaise and salad dressings. Additionally, eggs act as thickening agents in custards and sauces by coagulating when heated, which helps to give these dishes their desired consistency. Overall, eggs are invaluable for their functional properties in both sweet and savory culinary applications.

10.9 TECHNICAL TERMS:

Denaturation, Peptization, quality, emulsion.

10.10 SELF ASSESSMENT QUESTIONS:

1) Describe the composition and nutrient value of whole egg, egg whites, and egg yolks?
2) Describe the structure of an egg?
3) Discuss quality indicators of fresh eggs and describe the grading of fresh eggs?
4) Explain safe handling of eggs and egg products?
5) Identify ways that eggs are preserved and processed?
6) Describe the preparation of eggs and use of eggs in several types of dishes?
7) Describe the coagulation of eggs by heat and by mechanical beating?
8) Explain the reasons for the development of a green color in cooked eggs?
9) Describe egg substitutes and their use in food preparation?

10.11 REFERENCES:

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Dr. Ch. Manjula

LESSON-11

MEAT AND POULTRY: STRUCTURE, MUSCLE COMPOSITION, POST-MORTEM CHANGES, HEAT INDUCED CHANGES IN MEAT, TENDERNESS-TENDERIZERS

OBJECTIVES:

After going through this lesson students will understand:

- To understand the structural components of meat and poultry, including the muscle tissue, connective tissue and fat and how these impact the texture and quality of the meat.
- To understand the biochemical and physiological changes that occur in meat after the animal is slaughtered, and how these changes affect the quality and aging of the meat.
- To explore methods to enhance meat tenderness, including natural and chemical tenderizers, and understand how tenderness is a key factor in meat quality.

STRUCTURE:

11.1 INTRODUCTION:

Meat and poultry are essential food sources, providing high-quality protein, essential amino acids, vitamins, and minerals necessary for human health. Meat refers to the flesh of animals such as beef, pork, and lamb, while poultry includes domesticated birds such as chicken, turkey, and duck. These foods have been a staple in human diets for centuries due to their nutritional value and versatility in cooking. In food science, meat and poultry are

studied for their composition, processing, preservation, and role in food product development. Understanding their physical and chemical properties helps improve quality, safety, and innovation in the food industry.

Meat and poultry are composed primarily of muscle fibers, connective tissue, fat, and water. These components determine characteristics such as texture, tenderness, juiciness, and flavor. Factors such as the animal's age, diet, breed, and processing methods affect the final product's quality. Poultry is generally leaner than red meat, making it a popular choice for health-conscious consumers. Processing techniques such as freezing, curing, smoking, and marination help enhance shelf life and flavor while ensuring safety. Scientific advancements in meat tenderization and alternative meat products contribute to expanding options for consumers with different dietary preferences.

Food safety is a crucial aspect of meat and poultry consumption, as they are susceptible to contamination by harmful bacteria like Salmonella, E.Coli, and Listeria. Proper handling, storage, and cooking to recommended internal temperatures help prevent food borne illnesses. In recent years, food scientists have also explored plant-based and lab-grown meat alternatives to address environmental and ethical concerns. These innovations aim to replicate the taste, texture, and nutritional value of traditional meat while promoting sustainability. By studying meat and poultry through food science and experimental research, experts continue to develop safer, healthier, and more efficient food products for global consumption.

11.2 STRUCTURE:

Meat and poultry are primarily composed of muscle tissue, which is responsible for their texture, tenderness, and overall quality. The basic structural unit of muscle is the muscle fiber, made up of proteins such as myosin and act in, which play a role in muscle contraction. These fibers are grouped into bundles surrounded by connective tissue, forming the overall structure of meat. The proportion and arrangement of these fibers influence the texture-meats with finer muscle fibers, such as poultry, tend to be moretender, while meats with coarser fibers, like beef, are often tougher. Additionally, the presence of marbling (intramuscular fat) contributes to the juiciness and flavor of meat.

Connective tissue plays a crucial role in meat structure and texture. It consists mainly of collagen and elastin, which provide support and structure to the muscles. Collagen is a protein that breaks down into gelatin when cooked slowly, leading to tenderization, whereas elastin does not break down easily and contributes to toughness. The amount of connective tissue varies between different cuts and types of meat-muscles that undergo more movement, such as the legs, contain higher amounts of connective tissue, making them tougher than less-used muscles like the loin. Poultry generally has less connective tissue than red meat, making it cook faster and remain moretender.

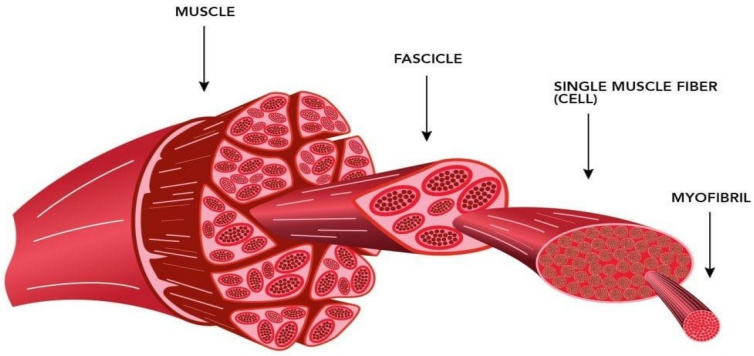

Fig. 11.2.1 Structure of Meat

Fat and water content also play a vital role in the structure and sensory characteristics of meat and poultry. Fat is found in three forms: subcutaneous fat (under the skin), intermuscular fat (between muscles), and intramuscular fat (marbling). Marbling enhances tenderness and flavor by keeping the meat moist during cooking. Water makes up a significant portion of meat, affecting its weight, texture, and juiciness. During cooking, water loss impacts the final product's tenderness and succulence. Understanding the structure of meat and poultry helps in optimizing processing techniques, cooking methods, and product innovations to enhance quality and consumer satisfaction.

11.3 MUSCLE COMPOSITION:

The muscle composition of meat and poultry is primarily made up of muscle fibers, connective tissue, fat, and water. These components contribute to the texture, flavor, and nutritional value of the meat.

1) Muscle Fibers:

Skeletal Muscle Fibers: The main component of meat, muscle fibers (or myofibrils) are long, cylindrical cells that contract to facilitate movement. These fibers are made up of smaller units called myofilaments (actin and myosin), which are responsible for muscle contraction.

Types of Muscle Fibers:

- Slow-twitch fibers (Type I): These fibers are more efficient in using oxygen and are associated with endurance. They are found more in muscles that are used for sustained activities (e.g., chicken breast).
- Fast-twitch fibers (Type II): These fibers are better at generating quick bursts of power and are found in muscles that are used for short, intense activities (e.g., chicken legs or turkey thigh).
- The ratio of slow-twitch to fast-twitch fibers influences the texture of the meat. Muscles that are used more frequently (such as the legs and thighs of poultry) tend to have more fast-twitch fibers and are therefore darker and tougher.

2) Connective Tissue:

Collagen: This protein is a major component of connective tissue in meat. It provides structural support and contributes to the toughness or tenderness of meat. Collagen is found more abundantly in muscles that are exercised more frequently, like in poultry legs or beef shank.

- Gelatin: When cooked, collagen breaks down into gelatin, which adds a rich, moist texture to stews or slow-cooked meats.
- Elastin: Another protein found in connective tissue, elastin is less abundant than collagen and contributes to the elasticity of meat. It is more prevalent in older animals, making meat tougher.

3) Fat:

- Intramuscular fat (Marbling): This fat is dispersed within the muscle fibers and contributes to flavor, tenderness, and juiciness. Marbled meats (such as well-marbled beef cuts) tend to be more tender and flavorful due to the fat.
- Subcutaneous fat: This is fat found just beneath the skin. It can be visible (such as the fat layer on a chicken breast) and helps retain moisture during cooking.
- Intermuscular fat: Fat located between muscle groups, particularly noticeable in larger cuts of meat.

4) Water:

Water makes up a large portion of meat (typically 60-75%). Water is crucial for the meat's texture and juiciness, but it can be lost during cooking, leading to a reduction in weight.

- **Minerals:** Meat contains essential minerals like iron, zinc, and phosphorus, which contribute to its nutritional value.
- **Vitamins:** Poultry and meat provide B-vitamins, including niacin, riboflavin, and B12, which are essential for energy metabolism.
- **Proteins:** Meat is rich in high-quality proteins, containing all nine essential amino acids.

11.4 POSTMORTEM CHANGES:

After an animal is slaughtered, significant biochemical and structural changes occur in the muscle tissue, transforming it into meat. These post-mortem changes impact meat quality, affecting texture, color, tenderness, water-holding capacity, and flavor. The key post-mortem changes include glycolysis and pH decline, rigor mortis, resolution of rigor, proteolysis, and aging. Understanding these processes is crucial for meat scientists, processors, and the food industry to optimize meat quality and ensure safety for consumers.

1) Glycolysis and pH Decline:

Immediately after slaughter, the oxygen supply to the muscles is cut off, and the body shifts to anaerobic metabolism. Stored glycogen in the muscle is broken down through glycolysis, producing lactic acid. This leads to a decline in pH, typically from about 7.0 in living muscle to 5.4–5.8 in post-mortem meat. The rate and extent of pH decline significantly affect meat quality. A rapid pH drop while the carcass is still warm can lead to pale, soft, and exudative (PSE) meat, common in pork and poultry, whereas a limited pH drop results in dark, firm, and dry (DFD) meat, often seen in beef and lamb due to stress before slaughter.

2) Rigor Mortis (Stiffening of Muscles):

Rigor mortis, meaning “stiffness of death”, occurs when the muscle contracts and stiffens due to the depletion of adenosine triphosphate (ATP). ATP is essential for muscle relaxation, but once it is used up, actin and myosin proteins form irreversible cross-links, causing muscle stiffening. The onset of rigor mortis depends on species, muscle type, and temperature. In poultry, rigor may set in within 1-2 hours, while in pork, it takes 4-6 hours, and in beef, it can take 6–12 hours. Proper chilling is essential during this phase to prevent excessive contraction, which can cause tough meat.

3) Resolution of Rigor Mortis and Tenderization:

After reaching peak rigor, meat begins to gradually tenderize as muscle proteins start breaking down. This process is influenced by enzymes such as calpains and cathepsins, which degrade structural proteins, leading to improved tenderness. If the meat is not properly handled during this stage, it may become overly tough. Cold shortening can occur when carcasses are rapidly chilled before rigor mortis, leading to excessive contraction and tough meat. Conversely, electrical stimulation post-slaughter can accelerate glycolysis and reduce the risk of cold shortening by hastening the onset of rigor mortis.

4) Proteolysis and Meat Aging:

As meat continues to age post-mortem, proteolytic enzymes break down myofibrillar proteins, improving tenderness and texture. This aging process can last from a few days to several weeks, depending on temperature and storage conditions. Wet aging (storing meat in vacuum-sealed packaging under refrigeration) and dry aging (exposing meat to controlled air circulation) are common techniques used to enhance flavor and tenderness. Dry-aged meat develops a distinct taste due to oxidation and enzymatic reactions, while wet-aged meat retains more moisture and has a milder flavor.

5) Meat Quality and Final Characteristics:

Post-mortem changes significantly influence meat color, tenderness, water-holding capacity, and flavor. The conversion of myoglobin, the muscle pigment, determines the meat's color-bright red oxymyoglobin in fresh meat, brown metmyoglobin in oxidized meat, and purple

deoxy-myoglobin in vacuum-sealed meat. Proper handling and chilling prevent excessive moisture loss, ensuring juiciness and a desirable texture. Factors like stress before slaughter, chilling rate, and storage conditions all impact the final product's quality. By controlling post-mortem processes, meat scientists and processors can optimize meat characteristics for consumer satisfaction and industry standards.

6) Temperature:

Temperature of animal increases from 37.6 C-39 C. This is the reason why animal cools slowly during refrigeration as aa result of continuous production of heat.

11.5 HEAT INDUCED CHANGES IN MEAT:

Heat-induced changes in meat involve complex physical and chemical reactions that alter the texture, flavor, color, and nutritional content of the meat.

1) Protein Denaturation and Coagulation:

- **Collagen Breakdown:** Collagen, a connective tissue protein found in muscle, is responsible for the toughness of some cuts of meat. When meat is heated, collagen undergoes denaturation, which means the triple helix structure of the collagen breaks down. This transformation into gelatin occurs most effectively at temperatures above 70°C (160°F). Gelatin is a more soluble and tender form of collagen, which is why slow cooking methods (such as braising, stewing, or slow roasting) can make tough cuts like brisket or chuck more tender.
- **Myosin and Actin Denaturation:** Myosin and actin are the proteins that make up muscle fibers. As meat is heated, these proteins begin to denature (unravel and lose their original structure). At temperatures above 40°C (104°F), the myosin proteins begin to coagulate, causing the muscle fibers to contract. This process squeezes out water from the meat, leading to moisture loss and changes in texture. At around 70°C (160°F), actin begins to denature as well, making the muscle fibers less flexible and resulting in firmer meat.
- **Tenderness vs. Toughness:** The overall tenderness of meat is a balance between the breakdown of tough connective tissues (like collagen) and the coagulation of muscle proteins (myosin and actin). If meat is cooked too quickly or at too high a temperature, the proteins coagulate too rapidly, leading to a tough texture. On the other hand, slow and low cooking allows collagen to break down into gelatin, making the meat more tender.

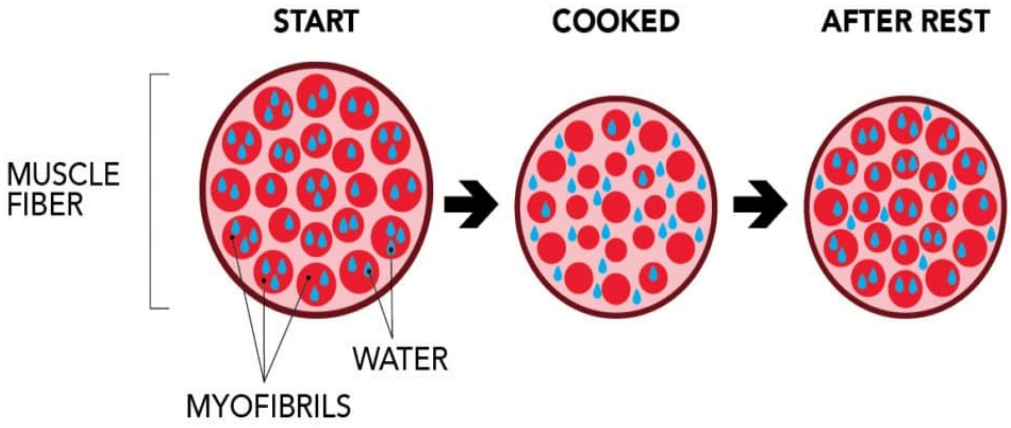

Fig 12.5.1 Effect of Heat on Muscle Fibers

2) Water Loss and Moisture Retention:

- Water Evaporation: As heat increases, muscle fibers contract and expel water. This process begins around 50°C (122°F) and intensifies as the temperature rises. Meat with a high fat content or connective tissue will generally retain moisture better during cooking. However, prolonged exposure to heat causes more water to be lost, leading to a drier texture.
- Moisture Loss in Cooking Methods: Different cooking methods affect water retention differently:
    i) Grilling, roasting, and pan-searing: These methods typically result in higher moisture loss because of the high, direct heat. They create a browned, caramelized exterior, but also cause dehydration of the interior.
    ii) Braising and stewing: These methods involve cooking meat in liquid at lower temperatures, which can help retain moisture and break down collagen, yielding tender results.
    iii) Sous-vide: This method, where meat is cooked in a vacuum-sealed bag at low temperatures for a long period, helps retain almost all the moisture, making it tender and juicy.

3) Fat Melting and Rendering:

- Fat Breakdown: Meat fat consists of triglycerides, which are broken down into free fatty acids and glycerol when heated. The melting point of fat varies depending on the type of fat in the meat. For instance, beef fat starts to melt at around 40°C (104°F), while pork fat begins to melt at about 50°C (122°F). The rendered fat contributes to both flavor and moisture.

- Effect on Flavor: The melting fat helps carry flavors throughout the meat and creates a more succulent texture. Fat also reacts with heat to create volatile compounds that contribute to the aroma and flavor of cooked meat. For example, beef tallow can develop a rich, savory taste when rendered.

4) Maillard Reaction (Browning and Flavor Development):

- **Browning:** The Maillard reaction is a complex chemical reaction between amino acids (from proteins) and reducing sugars (from carbohydrates). It occurs at higher temperatures, usually above 140–165°C (285–330°F). This reaction produces hundreds of compounds that are responsible for the rich brown color and deep, savory flavors that develop on the surface of roasted or grilled meat. The Maillard reaction is a key component in the creation of the characteristic grilled, roasted, or browned flavor in meat.
- **Flavor Development:** As the Maillard reaction continues, it creates a variety of flavor compounds such as pyrazines, thiols, and heterocyclic compounds. These contribute to the umami taste (savory and meaty) and are a significant part of the flavor profile that people associate with cooked meat.

5) Caramelization of Sugars:

Caramelization: In addition to the Maillard reaction, some meats (especially those with sugar or sweet marinades) will undergo caramelization during cooking. This process occurs when sugars (such as those in marinades or meat juices) break down at temperatures around 160°C (320°F). This creates caramel-like flavors and brown color. Caramelization typically occurs in the presence of heat over a longer period and contributes to the sweetness of roasted or grilled meats.

6) Color Changes:

- Raw to Cooked Color Transition: Raw meat is typically red or pink due to the presence of myoglobin, a protein in muscle cells that binds oxygen. When heat is applied, myoglobin undergoes changes that cause the color of the meat to change.
- Beef: At low temperatures, beef remains red due to the presence of myoglobin, but as it heats up, the color changes to brown as the myoglobin denatures and the meat oxidizes.
- Poultry and Pork: Poultry and pork can undergo similar color changes, but they also lose their pink color at different temperatures. For example, poultry starts turning white as it cooks due to myosin denaturation and the breakdown of heme iron in myoglobin.
- Internal Doneness: As meat continues to cook, the internal color transitions from pink/red to brown/gray. The degree of this color change correlates with the internal temperature and level of doneness, such as rare, medium, or well-done.

7) Nutrient Loss:

- Vitamins: Heat can lead to the loss of water-soluble vitamins, especially B-vitamins (such as B1, B2, B6, B12) and vitamin C, which degrade at high temperatures. Cooking methods like boiling or frying cause a greater loss of these nutrients compared to methods like steaming or sous-vide, which preserve more vitamins.
- Minerals: Minerals (such as iron, zinc, and phosphorus) are typically more stable during cooking, but cooking meat in water or broth can result in the leaching of some minerals into the liquid, reducing the nutrient content in the meat itself.

8) Texture Changes:

- Tenderization: Slow cooking methods like braising or slow roasting break down collagen into gelatin, making tough cuts of meat tender and juicy. This process works best at lower temperatures over extended cooking times.
- Toughening: High-heat methods (grilling, pan-searing) can cause rapid protein coagulation, squeezing out moisture and making the meat tough if overcooked. The key is to find the right balance of time and temperature for the desired texture.

9) Volatile Compounds and Aroma:

As meat cooks, it releases various volatile organic compounds (VOCs), which contribute to the aroma of cooked meat. Some of these compounds are the result of fat breakdown, Maillard reactions, or the burning of sugars. This is why the smell of cooking meat is often associated with its deliciousness. These compounds can include aldehydes, ketones, and sulfur compounds, depending on the cooking method and type of meat.

11.6 TENDERIZATION:

Tenderization of meat refers to the process of breaking down the muscle fibers and connective tissues to make it more tender, palatable, and easier to chew. This process can be achieved through natural, mechanical, or chemical methods.

11.6.1 Factors Affecting Meat Tenderness:

Several factors influence meat tenderness:

1) Cut of Meat: Muscles used less frequently (e.g., tenderloin, ribeye) are naturally more tender than active muscles (e.g., brisket, shank).
2) Age of the Animal: Meat from younger animals is generally more tender than from older animals.
3) Marbling (Intramuscular Fat): Fat within the muscle enhances tenderness by lubricating muscle fibers.
4) Connective Tissue Content: More collagen (connective tissue) makes meat tougher. Slow cooking can break down collagen into gelatin, improving tenderness.

5) Cooking Method: Dry heat (grilling, roasting) can toughen lean cuts, while moist heat (braising, stewing) helps break down tough fibers.

11.6.2 Methods of Meat Tenderization:

1) Natural Tenderization:

These methods rely on time and biological processes:

- Dry Aging: Meat is stored at controlled temperature and humidity, allowing enzymes to break down muscle fibers, enhancing tenderness and flavor.
- Wet Aging: Meat is vacuum-sealed and aged in its own juices, using natural enzymes to improve tenderness.

2) Mechanical Tenderization:

Physical techniques that break down muscle fibers include:

- Pounding: Using a meat mallet to break down muscle structure.
- Blade or Needle Tenderization: Machines with needles or blades pierce the meat to break connective tissue.
- Grinding or Mincing: Reduces meat fibers into small pieces, making it more tender (used for ground meat).

3) Chemical Tenderization:

Certain chemicals help break down proteins in meat:

- Acidic Marinades: Vinegar, lemon juice, yogurt, and buttermilk help break down proteins, enhancing tenderness.
- Salt and Brining: Salt disrupts protein structures, making meat retain moisture and become tender.

4) Enzymatic Tenderization:

- Papain (from papaya) and Bromelain (from pineapple) break down proteins.
- Ficin (from figs) and Actinidin (from kiwifruit) are also effective tenderizers.

5) Cooking Methods for Tenderization:

- Slow Cooking (e.g., braising, stewing): Converts tough collagen into gelatin, making meat moist and tender.
- Sous Vide Cooking: Cooking meat at low temperatures for an extended time in a vacuum-sealed bag ensures even tenderization.
- Resting After Cooking: Letting meat rest after cooking allows juices to redistribute, making it more tender.

11.7 CONCLUSION:

Enzymes like papain and bromelain can further improve tenderization. By recognizing the Effects of heat on meat we can achieve more tender juicy and flavorful meat products that meet consumer Expectations. Understanding post-mortem changes and meat composition is crucial for optimizing meat quality, safety, and nutritional value. Factors like breed, diet and aging can significantly impact meat composition, making it essential to control these variables to produce high-quality meat products. By recognizing the complex interactions between post-mortem changes, meat composition, and external factors, the meat industry can strive to provide better products for consumer. Meat cooking in rural and small urban communities is increasing tremendously. Hence the cooking of meat attains importance and knowledge of what happens to the meat during cooking gives understanding of why it should be cooked soon after defrosting, if it is defrosted before cooking. Cooking method, changes in cooking because meat may account for the largest portion of food cost.

11.8 SUMMARY:

Meat and poultry consist of muscle fibers, connective tissue, fat, and sometimes bone, all of which contribute to the texture, flavor, and structure of the meat. After slaughter, meat undergoes postmortem changes such as rigor mortis (stiffening of muscles) and a decline in pH, which affects its color and texture. The muscle proteins, like myosin and actin, denature when heat is applied, causing the meat to shrink and change in texture. Collagen, a key component of connective tissue, breaks down into gelatin when exposed to heat, which helps tenderize tougher cuts. Tenderness in meat is influenced by factors such as the animal's age, the muscle's use, and the conditions under which the meat is aged. To improve tenderness, mechanical methods like pounding or enzymatic tenderizers can be used, along with acidic marinades or salt, which help break down proteins and connective tissue. These processes are crucial for improving the eating quality of meat, especially tougher cuts.

11.9 TECHNICAL TERMS :

Tenderizer, rigor mortis, gelatin, post-mortem changes, collagen, myosin, fibrils, proteolysis.

11.10 SELF ASSESSMENT QUESTIONS:

1) Explain the role of meat in our diet?
2) Discuss the postmortem changes in meat?
3) List the methods of cooking in meat?
4) Describe the storage changes in meat?

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Dr. Ch. Manjula

LESSON-12

FISH AND MARINE FOODS: CLASSIFICATION AND COMPOSITION, SELECTION OF COOKING

OBJECTIVES:

After going through this lesson students will understand:

- To understand and categorize fish based on various factors, including species,
- Nutritional composition, and market classification, to ensure proper preparation and cooking methods.
- To choose the most appropriate cooking method for a specific type of fish based on its texture, flavor, fat content, and desired outcome.

STRUCTURE:

12.1 INTRODUCTION:

India has a coast line of 5,100 km. Over 200 edible fish varieties are known commercially important. Marine types are sardines, mackerel, tuna, catfish, scombroids, brown duck, ribbon fish, prawns and cuttle. Carps, rohu, mrigal, hilsa are the main catch from inland

water. In India bulk of the fish is sold in fresh (65- 70%) and dried (10-15%) condition with very little processing and value addition. Although fish contain complete proteins and can be an alternative for meat in the diet, fish consumption per capita is far lower than that of meat. Fish and marine foods are adiverse and important source of nutrition worldwide. Marine food, also known as sea food, is food that comes from these a, including fish and shellfish. It's a significant source of protein and nutrients and is associated with health benefits like reduced risk of cardiovascular disease. All fish are cold-blooded animals that live in the water. They have backbones, fins, and gills. There are 32,000 different species of fish.

12.2 CLASSIFICATION OF FISH:

Edible fish are categorized as either fin fish or shell fish. The term fin fish refers to the fishes that have bony skeleton. Most fin fish come from salt water however, great lakes and inland water add considerable amounts to the total catch. Edible shell fish are mainly salt-water fish. Shell fish is used to designate both mollusks and crustaceans.

- Shellfish are highly perishable. They are best when purchased directly from the fisherman. They may be expensive at shops in in land areas because of their very short storage life. The consumption and demand for shellfish, especially shrimps and prawns, has increased since frozen products became widely available.

- Crustacea have legs with partly jointed outer shells. They includecrabs, lobsters, prawns and shrimps. The densecoarse flesh is found mainly in the claws and tail, e.g., in the lobster and crab. This flesh is not as digestible as other types of fish. Lobsters and crabs are best kept alive up to the point of their cooking or freezing, otherwise they deteriorate in quality in a matter of a day or less.

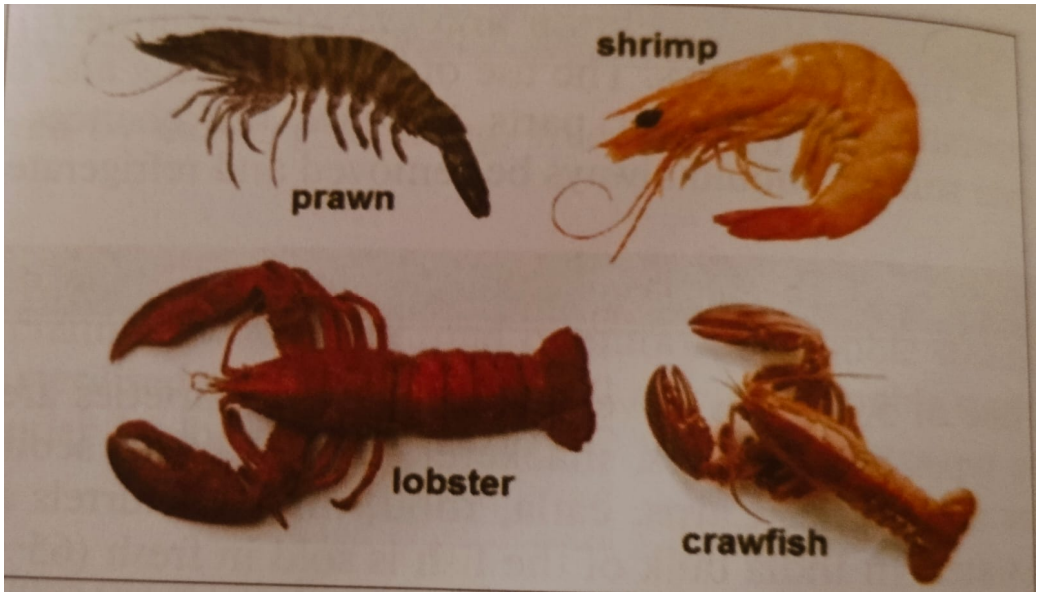

Fig 12.2.1 Different Types of Crustaceans

Source: Food Science B.Srilakshmi

Mollusks have harder outer shells and nolegs. They have hinged shells like oysters, scallops and mussels. Others have shells in one piece like snails, cockles and winkles.

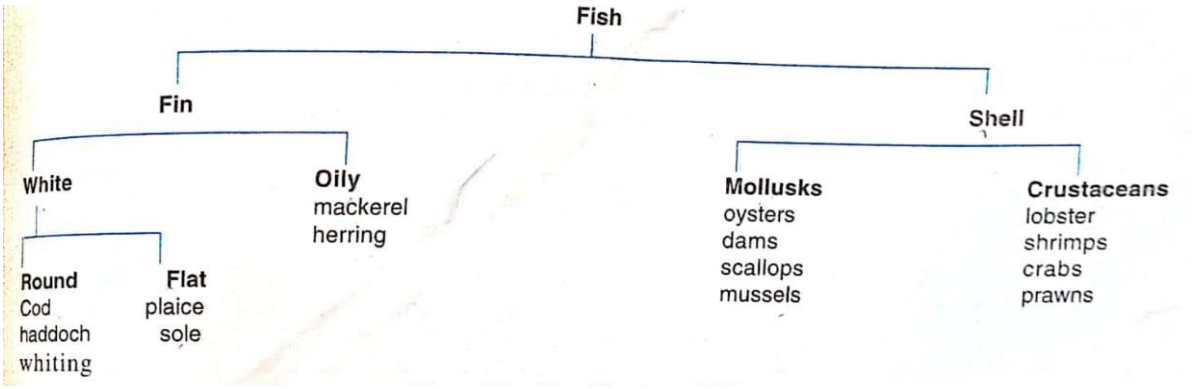

Fig. 12.2.2 Classification of Fish

Source: Food Science 7th Edition

12.3 COMPOSITION OF FISH:

Fish is a highly nutritious food source, composed primarily of water, protein, fat, minerals, and vitamins. Composition of Fish. Fish is an important source of high-quality protein, essential fatty acids, vitamins, and minerals, making it a valuable component of a healthy diet. The composition of fish varies based on species, habitat (freshwater vs. marine), diet, and seasonal changes. Generally, fish have a lower fat content compared to meat and poultry, with a higher proportion of unsaturated fats, particularly omega-3 fatty acids. The key components of fish include water, protein, fat, ash (minerals), and vitamins, each playing a crucial role in its nutritional value and functional properties.

12.3.1 Water Content:

Fish have a high water content, typically ranging from 65% to 80% of their total weight. This makes fish highly perishable, as the high moisture content promotes microbial growth and enzymatic activity. Lean fish, such as cod and haddock, have a higher water content, while fatty fish, like salmon and mackerel, have a lower water percentage due to higher fat levels. The water-holding capacity of fish influences its texture, juiciness, and processing properties.

12.3.2 Protein:

Fish is an excellent source of high-quality protein, usually making up 15% to 25% of its composition. The proteins in fish are easily digestible and contain all essential amino acids, making them a complete protein source. The muscle proteins in fish include myofibrillar proteins (actin and myosin), which contribute to muscle contraction and texture, and sarcoplasmic proteins, which influence flavor. Fish also contain collagen, but in lower amounts than meat, which is why fish muscle is more tender and flakes easily when cooked.

12.3.3 Fat:

Fish fat content varies significantly among species, ranging from 0.5% in lean fish (e.g., cod,

haddock) to over 20% in fatty fish (e.g., salmon, mackerel, herring). Unlike meat and poultry, fish fat is rich in omega-3 polyunsaturated fatty acids (PUFAs), such as EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), which are beneficial for heart and brain health. The presence of these healthy fats makes fish a recommended food for reducing cardiovascular disease risk. However, fish fat is also more prone to oxidation, leading to rancidity if not stored properly.

12.3.4 Vitamins:

Fish are rich in water-soluble (B-complex) and fat-soluble (A, D, and E) vitamins. B-complex vitamins, including B12, niacin, and riboflavin, are essential for energy metabolism and nerve function. Fatty fish, such as salmon and tuna, are excellent sources of vitamins A and D, which support vision, immune function, and bone health. Vitamin E, an antioxidant, is also found in fish fat and helps prevent lipid oxidation.

The unique composition of fish makes it a highly nutritious and functional food. Its high protein digestibility, low collagen content, and abundance of omega-3 fatty acids set it apart from other animal protein sources. However, due to its high water content and unsaturated fat levels, fish require careful handling, storage, and processing to maintain quality and prevent spoilage.

12.4 SELECTION OF FISH:

Selection of fish is based on several factors to ensure freshness, quality, and suitability for consumption. The key criteria include:

1) Eyes: Clear, bright, and slightly bulging (not sunken or cloudy).
2) Skin & Scales: Moist, shiny, and firmly attached. Dull or dry skin indicates loss of freshness.
3) Gills: Bright red or pink with no slime or discoloration. Brown or gray gills suggest spoilage.
4) Flesh: Firm and elastic. Pressing the flesh should cause it to spring back. Soft, mushy flesh indicates spoilage.
5) Belly Cavity: Intact with no signs of breakage, swelling, or strong odors.
6) Fresh fish should have a mild, ocean-like or freshwater smell.A strong ammonia, sour, or rotten odor indicates decomposition.
7) Fresh fish have bright red blood; dark or brownish blood suggests age.
8) White-fleshed fish should be translucent and moist, not dull or dry.
9) Slimy, sticky surface, discolored patches on flesh, fins that are dry, brittle, or curling are the signs of spoilage.

Selection of Processed Fish:

- Frozen Fish: No ice crystals or freezer burn. Should be solid and not thawed.
- Canned Fish: No dents, rust, or bulging lids.
- Dried Fish: Evenly dried, no mold, and no off-putting odor.
- Smoked Fish: Even color, firm texture, and pleasant smoked aroma.

12.5 SELECTION OF CRABS:

Different species of crabs are used in food, and the selection may depend on culinary preferences or regional availability.

1) Freshness Indicators:

For Live Crabs:

- Activity Level: Choose crabs that are active and move when handled. A sluggish or inactive crab might be dead or dying.
- Shell Condition: The shell should be hard (especially for hard-shell varieties like blue crabs), and free from cracks or damage. Soft-shell crabs should have a clean, intact exoskeleton.
- Smell: Fresh crabs should have a clean, ocean-like smell. Any strong or unpleasant odor is a sign of spoilage.

For Cooked or Frozen Crabs:

- Appearance: The meat should be firm and moist, not dry or mushy. The shell should not appear brittle or cracked.
- Packaging: For frozen crabs, ensure the packaging is intact, and there is no frost buildup inside the packaging (which indicates freezer burn).

1) Wild-caught crabs often have a stronger flavor and are preferred by some consumers for sustainability and natural feeding habits. Farmed crabs (or those raised in controlled environments) might have a more consistent size and texture, but they could also be less flavorful than wild-caught crabs.
2) Live crabs should be kept cool and moist, and they should be cooked within 24-48 hours to maintain freshness.
3) Frozen crabs should be stored at a consistent freezing temperature, and ideally used within 6 months for optimal flavor and texture.
4) Larger crabs like king crabs or Dungeness crabs are often boiled or steamed, while smaller crabs are used for dishes like crab cakes or soups. Soft-shell crabs are typically pan-fried or deep-fried after being cleaned.

12.6 SELECTION OF LOBSTERS:

The selection of lobster involves evaluating several factors that ensure freshness, quality, and safety, whether you are purchasing live, frozen, or cooked lobster.

1) **Freshness Indicators (Live Lobsters):**

   - Movement: Live lobsters should be active, moving their antennae and legs. A lack of movement or sluggishness is an indicator of stress or that the lobster may not be fresh.
   - Shell Condition: The lobster's shell should be firm and free of cracks or soft spots. A hard shell indicates a healthy lobster that has recently molted.
   - Claw Condition: Both claws should be intact, with the larger claw (crusher claw) being robust and hard. An injured or missing claw may indicate a stressed lobster.
   - Smell: Fresh lobsters should have a clean, briny, sea-like smell. Any strong or foul odor suggests spoilage, and the lobster should be avoided.
   - Color: Live lobsters are usually dark brown or greenish-brown, but after cooking, they turn a bright red. A pale lobster may indicate it is under stress or not healthy.

2) **Live Lobsters:** Should be kept cool and moist (in a cool, damp environment). They should not be submerged in water or stored in a sealed container, as they require oxygen.

3) **Frozen Lobsters:** Lobsters can be frozen either raw or cooked, but flash freezing (quick freezing) is best for preserving texture and flavor. Properly frozen lobsters can last up to 6 months.

4) **Cooked Lobsters:** Should be refrigerated and consumed within 1-2 days for best quality.

5) **Color and Appearance (for Cooked Lobsters):**

   - Bright Red Shell: Indicates that the lobster has been cooked properly. If the shell is pale or has an odd discoloration, it could be a sign that the lobster was not handled or cooked properly.
   - Meat Quality: The meat should be firm, moist, and translucent in uncooked lobsters. After cooking, the lobster meat should be opaque and springy to the touch. Any rubbery or mushy texture is a sign of overcooking or deterioration.
   - Claws and Tail: The lobster’s tail should be tightly curled underneath its body when cooked, a sign of freshness. If the tail is straight, it may indicate the lobster was dead before cooking.

6) Lobster meat should have a delicate, sweet flavor and a firm, yet tender, texture. Overcooking can lead to tough, rubbery meat, while undercooking can cause the meat to be mushy.

7) High-quality lobster meat should be pale white, with a clean, pure look, free from any dark spots, which could indicate spoilage.

12.7 SELECTION OF OYSTERS:

Oysters are a popular shellfish, known for their unique texture and briny flavor. When selecting oysters for consumption, it is essential to ensure that they are fresh, safe to eat, and of high quality.

1) Shell Condition:

Oysters should be tightly closed when handled. Open shells may indicate a dead oyster, which is unsafe to eat. If an oyster shell is slightly open, tap it lightly. A live oyster should close its shell immediately. The shell should be intact and free from cracks or damage. Broken shells could indicate improper handling or age.

2) Smell:

Fresh oysters should have a clean, ocean-like smell-briny and slightly sweet. An overly fishy or sour smell indicates spoilage. If the oyster emits a foul or unpleasant odor, discard it immediately.

3) Appearance of the Oyster Meat:

The meat should be plump and moist. It should be attached to the shell and look slightly glossy, indicating it is fresh and hydrated. The flesh color will vary slightly depending on the type of oyster but should not appear dry, discolored, or slimy.

4) Shell Shape:

Oysters can have different shell shapes based on their environment. A well-formed shell is a sign of a healthy oyster, while misshaped or irregular shells may indicate poor growing conditions or stress.

5) Harvesting Method and Location

Wild-caught oysters have a more complex flavor due to their natural diet in the wild. Farmed oysters are more consistent in size and taste but can be equally delicious if raised in healthy environments.

- **Taste:** Fresh oysters should have a clean, briny taste with a subtle sweetness. The flavor profile can vary depending on the species and the water in which they were harvested.
- **Texture:** The meat should have a smooth, tender, and slightly firm texture. If the oyster meat is rubbery, dry, or mushy, it may be past its prime.

12.8 COOKING OF FISH:

Fish is a highly versatile protein that can be cooked using a variety of methods, each affecting its texture, flavor, and nutritional profile. Due to its delicate muscle structure and low collagen content, fish requires minimal cooking time compared to meat and poultry. The method of cooking depends on the type of fish, its fat content, and the desired final texture. Cooking also enhances the digestibility of fish proteins and improves its flavor while preserving essential nutrients such as omega-3 fatty acids and vitamins. However, overcooking can cause the flesh to become dry and tough.

12.8.1 Methods of Cooking:

1. Grilling and Broiling:

Grilling and broiling are dry-heat cooking methods that expose fish to high temperatures, giving it a smoky, charred flavor. Grilling involves cooking over an open flame, while broiling uses heat from above. These methods work well for firm, oily fish like salmon, tuna, and swordfish, which can withstand high heat without falling apart. To prevent sticking, fish can be brushed with oil or placed on grill baskets. Overcooking should be avoided to maintain moisture.

2. Baking and Roasting:

Baking and roasting involve cooking fish in an oven at controlled temperatures. Baking is done at moderate heat (350-400°F or 175-200°C), making it suitable for delicate fish like cod, tilapia, and sole. Roasting, which is done at higher temperatures (above 400°F or 200°C), enhances the natural flavors of firm fish like halibut and trout. Fish can be cooked in parchment paper (en papillote) to retain moisture and infuse flavors with herbs, lemon, and spices.

3. Steaming and Poaching:

Steaming and poaching are moist-heat cooking methods that preserve the delicate texture and nutritional value of fish. Steaming involves cooking fish over boiling water, which keeps it tender and retains its natural flavors without added fats. Poaching, on the other hand, requires submerging fish in a liquid such as water, broth, or milk at a low temperature. These methods are ideal for lean, delicate fish such as sole, haddock, and flounder, as they prevent drying out.

4. Frying (Deep Frying, Pan Frying, and Sautéing):

Frying enhances the taste and texture of fish by creating a crispy outer layer. Deep frying involves submerging fish in hot oil, often after coating it with batter or breadcrumbs, making it popular for fish and chips. Pan frying uses less oil and is suitable for fillets of fish such as tilapia and snapper. Sautéing is a quicker method using minimal oil or butter, often with added seasonings. While frying adds flavor, it increases calorie content and may degrade healthy omega-3 fatty acids.

5. Boiling and Simmering (Fish Soups and Curries):

Boiling and simmering are used for making fish-based soups, stews, and curries. These methods involve cooking fish in a flavorful liquid, often with vegetables, spices, and herbs. Fish that holds its shape well, such as cod, mackerel, and catfish, is ideal for soups and curries. Simmering at a lower temperature helps retain the texture and prevents the fish from breaking apart. This method is widely used in Asian and Mediterranean cuisines.

Different cooking methods highlight the unique flavors and textures of fish, making it a versatile and healthy protein option. Choosing the right method depends on the type of fish, desired taste, and dietary preferences. Whether grilled, baked, steamed, or fried, fish can be prepared in countless ways to suit various cuisines and personal tastes.

12.8.2 Effects of Cooking on Fish:

- Protein Coagulation: Heat causes proteins (actin and myosin) to denature and coagulate, making the flesh firm and opaque.
- Moisture Loss: Overcooking causes excessive water loss, leading to dryness.
- Gelatinization of Collagen: Fish collagen breaks down quickly, making it tender.
- Flavor Development: Cooking enhances natural flavors and introduces new aromas.
- Nutrient Changes: Cooking can cause loss of heat-sensitive vitamins (B-complex, vitamin C), but omega-3 fatty acids remain stable if cooking temperature is controlled.

12.9 HEALTH BENEFITS OF FISH:

1) Rich Source of High-Quality Protein: Fish provides high-quality protein. Unlike some other animal proteins, fish is often lean, making it an excellent option for those looking for protein without excessive fat intake.
2) Omega-3 Fatty Acids for Heart Health: Omega-3 fatty acids, particularly EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), are abundant in fatty fish like salmon, mackerel, and sardines. These fatty acids provide several heart health benefits, including:
    - Reducing inflammation in blood vessels.
    - Lowering blood pressure and triglycerides.
    - Preventing arrhythmias (irregular heartbeats).
    - Reducing the risk of heart attacks and strokes.

3) Brain Function and Cognitive Health: Omega-3s in fish, particularly DHA, play a critical role in brain structure and function. These fatty acids are essential for:

- Cognitive development in children and adolescents.
- Cognitive maintenance in older adults, potentially reducing the risk of dementia and Alzheimer's disease.
- Enhancing memory and focus by supporting neuronal communication in the brain.

4) Support for Eye Health:

Omega-3 fatty acids also contribute to eye health by supporting the retina. Fish consumption can help protect against age-related macular degeneration (AMD), a major cause of blindness in older adults. The vitamin A in fish, especially from oily fish, helps maintain good vision and can prevent night blindness.

5) Vitamin D and Bone Health:

Fatty fish, particularly salmon, mackerel, and sardines, are excellent sources of vitamin D, a nutrient essential for:

- Calcium absorption and bone mineralization.
- Maintaining bone density and preventing diseases like osteoporosis.

6) Anti-Inflammatory Effects:

- Omega-3 fatty acids have well-documented anti-inflammatory properties, which can help manage chronic inflammatory conditions such as:
- Rheumatoid arthritis (reducing joint pain and swelling).
- Inflammatory bowel diseases (such as Crohn's disease and ulcerative colitis).
- Asthma and other respiratory issues.
- Regular fish consumption may help reduce the overall inflammation load in the body, which is beneficial for chronic disease prevention.

7) Cardiovascular Protection:

Fish, particularly fatty fish, has been shown to significantly reduce the risk of cardiovascular disease (CVD):

- Lowering LDL cholesterol (bad cholesterol) while boosting HDL cholesterol (good cholesterol).
- Reducing the risk of heart disease, stroke, and atherosclerosis (plaque buildup in the arteries).
- Regular fish consumption is associated with a lower risk of heart attacks and sudden cardiac death.

8) Weight Management:

Fish is naturally low in calories and fat compared to many other protein sources, making it a great option for those looking to manage their weight. The protein content in fish promotes feelings of fullness (satiety), which can help control overall calorie intake. Fish can be a valuable addition to weight loss diets by providing essential nutrients without the excess calories.

9) Skin Health:

The omega-3s in fish help maintain skin hydration and elasticity, which contributes to a healthy complexion and reduces signs of aging.Omega-3 fatty acids can help reduce the symptoms of eczema, psoriasis, and acne. Vitamin D, found abundantly in fish, also supports skin health and may help prevent certain skin conditions.

10) Mental Health Benefits:

Omega-3s are essential for maintaining brain structure and function and have been linked to mood regulation:

- Fish consumption has been associated with a lower risk of depression, anxiety, and bipolar disorder.
- Omega-3s play a role in the production of serotonin, a neurotransmitter that regulates mood.
- Regular consumption of fish is often recommended as part of a diet to support mental well-being.

11) Protection sgainst Certain Cancers:

- Some studies suggest that regular fish consumption may offer protection against certain cancers, particularly colorectal cancer.
- The omega-3s in fish are thought to have protective effects due to their ability to reduce inflammation and possibly slow tumor growth.

12.10 CONCLUSION:

Selecting and cooking fish and marine foods requires attention to freshness, sustainability, nutritional content, and cooking methods. By choosing the right cooking method and following simple cooking tips, you can unlock the full Flavors and nutritional potential of these incredible foods. Whether you're a seasoned chef or a culinary newcomer, exploring the word of fish and marine foods in a delicious and rewarding experience. fish and marine foods offer numerous health benefits and culinary delights. By selecting and classifying these foods based on freshness, sustainability, mercury levels, and nutritional content, consumers can make informed choices that support their health and well-being.

12.11 SUMMARY:

Marine life refers to the vast array of organisms that live in the ocean, from microscopic plankton to large marine mammals. Fish, as a significant component of marine life, have evolved to adapt to their aquatic environment, with specialized features like gills, scales, and fins for respiration, protection, and movement. The marine ecosystem is highly complex and includes coral reefs, estuaries, and deep-sea habitats that provide homes for diverse species. The interactions among different organisms form intricate food webs, where energy flows through various trophic levels. Factors like upwelling and ocean currents contribute to the productivity of marine environments, sustaining life across different depths. However, marine life is increasingly threatened by human activity, and efforts are being made globally to conserve marine biodiversity and restore ecosystems.

12.12 TECHNICAL TERMS:

Fish, Marine, Crustaceans, Sunken, Mollusks.

12.13 SELF ASSESSMENT QUESTIONS:

1) Write a short note on preservation of fish?
2) Explain changes and composition of fish?
3) Discuss the points remembered while cooking fish?

12.14 REFERENCES:

1) B. Sri Lakshmi, Food Science, 7th Edition.
2) Marine Foods and Fisheries.

Dr. Ch. Manjula

LESSON-13

SUGARS

OBJECTIVES:

After going through this lesson students will understand:

- Know the types of sugars
- Know the sugar crystals and sugar syrups

STRUCTURE:

13.1 INTRODUCTION:

Sugars are the building blocks of carbohydrates found in nature. They are present in milk, honey, maple syrup, and numerous fruits and vegetables. The most common sugars found in foods are single sugars called monosaccharides e.g. glucose, fructose and galactose and double sugars called disaccharides e.g. sucrose (table sugar), lactose (milk sugar) and maltose. There is no single component that can replace all of the functions of sugars in every product.

Glucose is found naturally in many foods and has a vital role in providing energy, in particular for the brain. Fructose is the sweetest of the naturally occurring sugars; many fruits and vegetables are rich in fructose. Sucrose (table sugar) is the combination of glucose and fructose linked together in a 1:1 ratio. Honey also contains glucose and fructose in a 1:1 ratio. Sugars provide sweetness and react with other ingredients to produce colour and flavour. They preserve food and fruits.

13.2 TYPES OF SUGARS:

The word “sugar,” generally thinks the white granulated version found in sugar bowls and tabletop packets. Such type of sugar is called sucrose. But there are many other types of sugars classified according to their chemical structures (Fig.1).

Simple sugars are monosaccharides. these are made up of single sugar molecules. The three main monosaccharides are fructose, galactose and glucose. These monosaccharides combine with various monosaccharides to form the disaccharides, these are most important in human nutrition: lactose, maltose and sucrose. The monosaccharide glucose is the common thread in each of these disaccharides. Glucose is part of sucrose (linked with fructose), lactose (linked with galactose), and maltose, (glucose linked with gucose).

Sugars occur naturally in a wide variety of fruits, vegetables and dairy foods. Sugars are added to foods as an ingredient that contributing to a food's structure and texture, adding sweetness and flavor enhancement, balancing acidity, controlling crystallization in confectionaries, providing a medium for the growth of yeast in baked goods and preventing spoilage by binding water to reduce its activity. Sugars are natural or added, most contain approximately 4 calories per gram. Here are some types of sugars that are found in whole and packaged foods:

Allulose:

A type of rare sugar that is found naturally in small quantities in brown sugar and maple syrup, as well as in dried fruits such as figs and raisins. Allulose contains fewer calories than sucrose. It may also be commercially produced from fructose or corn.

Fructose:

It is a hexose monosaccharide. It is a natural sugar. It is sweeter than sucrose. The richest sources are honey and ripe frits. It is used in confectionery to provide sweetness, flavor and colour.

Galactose:

A monosaccharide found naturally in milk and dairy foods, galactose combines with glucose to form the disaccharide lactose.

Glucose:

It is a natural sugar commonly called as dextrose in confectionery industry. Honey and fruits also contain glucose. The source of glucose of commercial manufacture is starch.

Lactose:

The sugar found naturally in milk, lactose is a disaccharide composed of one galactose molecule and one glucose molecule. Lactose is sometimes called "milk sugar."

Maltose:

A disaccharide composed of two glucose molecules, maltose is found in molasses and is used in fermentation.

Sucrose:

It is the sugar most people identify with the term sugar or sweetness. It occurs naturally as a component of carbohydrate of every fruit and vegetable. It is product of photosynthesis and occurs in greatest quantities.

Sugar Alcohols:

Sugar alcohols are neither sugar nor alcohol, but sugar alcohols are classified as a carbohydrates. Their chemical structure partially resembles a sugar and partially resembles an alcohol. Sugar alcohols are water-soluble compounds that are naturally produced in various plants as a result of photosynthesis. Sugar alcohols may also be commercially produced.

Sugar alcohols are a group of caloric sweeteners that are incompletely absorbed and metabolized by the body. Due to their incomplete absorption, sugar alcohols provide fewer calories than sugars and have less of an impact on blood glucose. Examples of sugar alcohols include erythritol, glycerin, maltitol, mannitol, sorbitol and xylitol. The caloric content of sugar alcohols ranges from 0.02 to 3 calories per gram, compared with 4 calories per gram for sugars. As a result, products sweetened with sugar alcohols may contain fewer calories than comparable products sweetened with sugars. Most sugar alcohols are less sweet than sucrose; maltitol and xylitol are about as sweet as sucrose.

Another term for sugar alcohols is polyols. For those following a low-fermentable-oligosaccharides-disaccharides-monosaccharides-and-polyols (FODMAP) diet, food sources of sugar alcohols must be monitored.

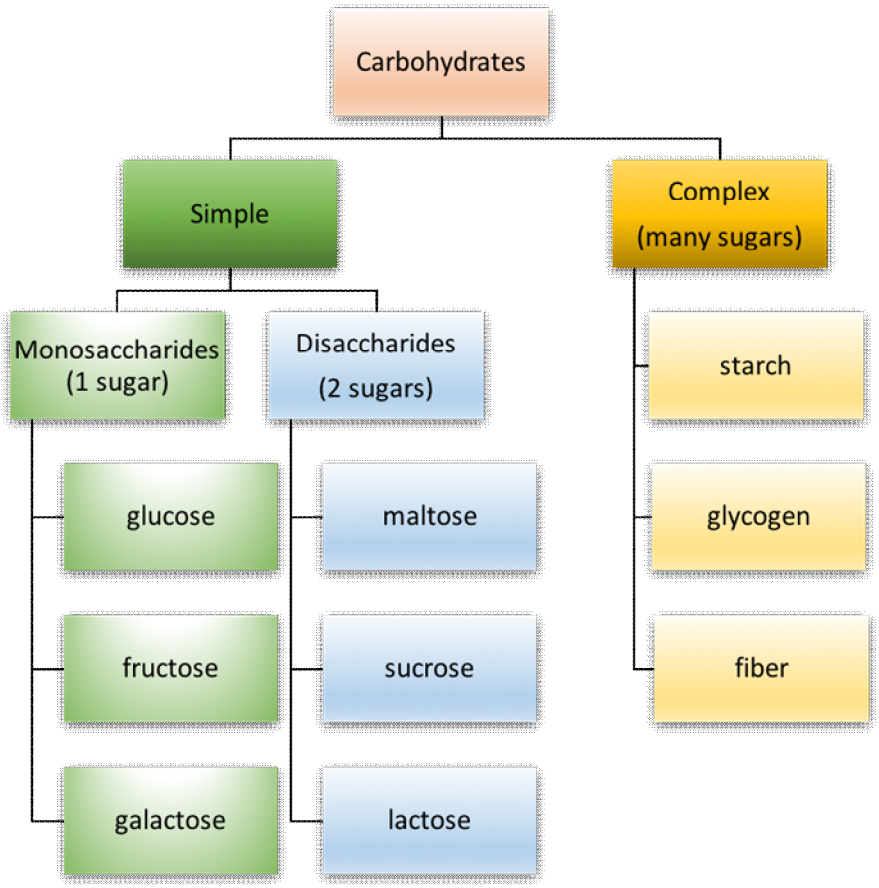

Fig. 1: Types of Sugars

https://media.lanecc.edu/users/powellt/FN225OER/Carbohydrates/FN225Carbohydrates2.html

13.3 SUGAR SYRUPS:

Dextrose Syrup:

The manufacture of dextrose from starch is a multi enzyme process. The carbohydrate composition in 94 to 98 % glucose, 1 to 3 % maltose and 1 to 2 % higher saccharide.

Corn Syrup:

It contains 75% carbohydrate and 25 % water. Acid and high temperatures are applied to hydrolyse cornstarch. The carbohydrate of the resulting product comprises from 36% glucose and from 99 to 20% maltose, the remainder consisting of higher sugars and dextrins. It inhibits crystallization in foods. It is useful in baked products. It enhances citrus flavor in fruit products used in cola beverages. Dried corn syrup is also available and is used in dry beverage mixes, instant breakfast mixes, cereal bars and sauce mixes. 16 % of liquid glucose is used in chikkis to get lighter colour and chewy taste.

High Fructose Corn Syrup:

It is manufactured from corn starch by enzymatic isomerisation. The enzymes used are alpha amylase, glucoamylase and glucose isomerase. It is sweeter than sucrose. HFCS inhibits crystallization in foods. It is useful in baked products and in cooking. It enhances citrus flavor in fruit products used in cola beverages. HFCS is marketed in three types 42%, 55 % and 90% fructose with the following composition. Fructose 42-90%, glucose 52- 90%, other sugars, 6-10%. HFCS is superior to sugar that at a given concentration, its osmotic pressure is twice that of sucrose.

Isomalt:

It is derived from beet sugar and is said to be similar to sugar in sweetness, taste, technological properties. Isomalt gives body and texture to foods unlike aspartame and saccharin. It is less hygroscopic and the product shelf life is better.

Maltodextrins:

These are prepared from corn starch by controlled enzymatic hydrolysis. Functional properties are low hygroscopicity, bland flavor, extremely low sweetness, potential of retarding crystal formation in ice creams. They can serve as fat substitute. Maltodextrins are useful in flavor encapsulation and prevention of oxidation of unstable compounds.

Molasses:

Molasses is the residue that remains after sucrose crystals have been removed from the concentrated juices of sugar cane or beet. It contains not more than 25% water and not more than 5% mineral ash.

After the first crystallization of sucrose, the molasses is high in sugar and light in colour. After the final process, a dark and bitter product with a relatively high mineral content, called black-strap molasses, remains.

Maple Syrup:

It is high prized of all syrups used for culinary and table purposes. It is made by evaporation of the sap of the sugar maple to a concentration containing not more than 35% water.

Honey:

Honey contains about 1% water and 82.5% carbohydrate with small amounts of minerals and vitamins and enzymes. The carbohydrate portion of honey includes 38% of fructose, 31% of glucose, 7% of maltose and 2% of sucrose. The colour of honey may vary from white to dark amber. The colour of fresh honey is related to its mineral content and is characteristic of its flowers-its source.

The long shelf life of honey is the low available water (17-18%) content. This low water content of honey and high osmostic nature do not support growth of microorganism or fermentation. Honey is used for the treatment of indigestion, coughs, colds and skin wounds.

Honey bees collect the nectar from flowers and deposit it in the hives where it is converted to honey. Bees die if they come in contact with toxins and thus do not bring pollutants in to the hive. Bees produce an enzyme, invertase that converts sucrose into glucose and fructose. Part of the glucose is converted to gluconic acid and hydrogen peroxide by another enzyme glucose oxidase. Gluconic acid reduces the pH of honey to the acidic range and makes it inhospitable for microbes. Hydrogen peroxide might also provide temporary protection against certain microbes.

Jaggery:

Jaggery is mainly obtained from sugar cane though it can also be prepared from plam, datepalm and coconut.

Cane is crushed and coarse suspended impurities from the juice are removed by straining and then the juice is boiled. Chemical clarificants are used to flocculate colloids present in the juice. After clarification, the cane juice is boiled vigorously to 115-177^{0}C with constant stirring and then concentrated into thick, almost semisolid mass, which on cooling solidifies into jiggery. Generally good quality jiggery has a light colour, good flavor, hardness, crystalline structure and good keeping quality. Is contains 65-85% sucrose, 10-15%invert sugar and it is very much preferred when non crystalline candies are prepared. It is specially used when it is used as binder in the preparation of chikki and puffed rice balls. It is also used in making sweet pongal, payasam and coffee. Jaggery is preferred to sugar because it is rich in iron, gives colour, has a typical flavor, gives body or thickness and it is less expensive.

Caramel Sugar:

The brown colour of caramels results chiefly from Millard reaction. It is obtained from sugars when they are heated either dry or with certain additives or in concentrated

solutions. Chemically caramel in polymeric in its character containing about 143 volatile and non volatile compounds. It contains caramelan, caramelen, caramelin methyl imidazole, furans fructose, glucose, alcohols, acids, aldehydes, esters, carbon dioxide and suphur dioxide as break down products.

It is used in brewing, vinegar making, blending of spirits like whisky, rum and wines as well as soft drinks. They are also used in biscuits, pickles, sauces and pastries. Caramel sugar can be prepared from soyabean, tapioca or sago. Caramel is a multi-purpose food additive contributing colour, flavor and sweetness to the product.

13.4 PROPERTIES OF SUGARS:

They play a significant role in moisture absorption. Sugars are hygroscopic. Among sugars fructose is more hygroscopic. Cakes made with honey, molasses remain moist for a long time.

Solubility:

In the natural state of foods, sugars are in solution. Crystallization of sugar occurs from a sufficiently concentrated sugar solution, and use of this is made in the commercial production of sugar from sugarcane and beets. The most soluble sugar is fructose, followed by sucrose and lactose. The sugar that is the most soluble such as fructose is most difficult to crystallize than that the least soluble sugar, lactose.

Acid Hydrolysis:

Sucrose is easily hydrolysed by acid but maltose and lactose are slowly acted on. The end products of sucrose hydrolysis are a mixture of glucose and fructose. This mixture is commonly called invert sugar. The monosaccharides are not appreciably affected by acids. Heat accelerates the action of acid.

Enzyme Hydrolysis:

The enzyme sucrase is also called invertase, used in the candy industry to hydrolyze some of the sucrose in cream fondant to fructose and glucose. This is done to produce soft, semifluid centers in chocolates. The enzyme is commonly added to the fondant layer around the fruit in chocolate coated cherries.

Caramelization:

With the application of sufficient dry heat, sugar melts or changes to a liquid state. Heating beyond the melting point brings about a number of decompositional changes. As sucrose melts around 160^0C, a clear liquid forms that gradually changes to a brown colour with continued heating. At about 170^0C, caramelisation occurs with the development of a characteristic caramel flavor along with the brown colour.

Decompositon by Alkalies:

The monosaccharides are markedly decomposed by alkalies and flavor may become strong and bitter. Sucrose is least affected by alkalies.

Sweetness:

Lactose is the last sweet, followed by maltose, galactose. Glucose and sucrose with fructose being the most sweet. A maximum sweetness from fructose is most likely to be achieved when it is used slightly with acid, cold foods and in beverages.

Fermentation:

Most sugars, except lactose, may be fermented by yeasts to produce carbon dioxide gas and alcohol. This is an important reaction in making bread and other baked products. The carbon dioxide leavens the product and the alcohol volatilizes during baking.

13.5 SUGAR CRYSTALS AND CONFECTIONS:

Sugar solutions are boiled and treated to produce either crystalline or non crystalline candies. Crystalline candies are usually soft. If properly made, crystalline candies are so smooth and creamy. The tiny sugar crystals in that cannot be felt on the tongue. The crystalline candies are fondant, mosore pak and coconut burfi.

Non crystalline candies are sometimes called amorphous which mean “without form”. In their preparation, by using various procedures, crystallization of sugar is prevented. Non crystalline candies may be chewy, such as caramels or hard such as butter scotch, toffees and brittles.

13.5.1 Crystalline Candies:

Fondant is the soft smooth candy that results from the cooking of a sucrose solution to a certain temperature, after which the solution is cooled and beaten until crystallization occurs. Addition of acid temperature, after which the solution is cooled and beaten until crystallization occurs. Addition of acid hastens inversion and use of milk or creams as the liquid, enhances the creamy nature of fondant.

Fondant:

As crystalline candy stands after crystallization is complete, it becomes somewhat more moist and smooth and knead easily, because some of the very small crystals dissolve in the syrup. Changes that occur during the initial period of storage are called ripening. Absorbed substances that interfere with crystallization aid in retarding the growth of crystals during storage. Fondants are used in making mints. Fondants are used in confectioneries for numerous purposes. Softened fondant is used in coating fruit and nut mixtures that are moulded and sliced.

Fudge:

The principles of making fudge do not differ from those of making fondant. Usually, the butter or margarine, the fat of chocolate and the milk furnish the substances that interfere with crystallization. The presence of substances that interfere with crystallization of sucrose in fondant and other candies is desirable, but at an optimum level. Glucose, corn syrup or

invert sugar either added directly or formed by acid hydrolysis affect crystallization because they make the sugar solution more soluble and therefore, decrease the ease of crystal formation. Other substances including fats from milk, cream, butter, margarine and chocolate and proteins from milk and egg white do not themselves crystallize. They physically interfere with the process of crystallization, retarding the growth of crystals. All these interfering substances aid in fine crystal formation and smooth texture in crystalline candies

The temperature at which crystallization occurs affect the size of crystals, primarily because it affects the rate of crystallization. In general, the higher the temperature at which crystallization occurs, the faster the rate of crystallization and the more difficult is to keep the crystals separated, resulting in larger crystals. Cooling the mixture to about 40^0C before starting to beat it favours the formation of more nuclei and finer crystals. The viscosity of a solution is also greater at lower temperatures. High viscosity is a further aid in the production of fine crystals because it retards crystallization. Too low a temperature may also hinder the formation of many nuclei.

13.5.2 Non Crystalline Candies:

Sugar does not crystallize in non crystalline candies. The crystallization is prevented by cooking at very high temperature so that the finished product hardens quickly before the crystals have a chance to form, adding such large amounts of interfering substances that the crystals cannot form or combining these methods.

Brittles:

Brittles are cooked to temperatures that are high enough to produce a hard, brittle candy that solidifies before it has a chance to crystallize. The brown colour and characteristic flavor of brittles result from non enzymatic browning reactions, probably both the millard type and the caramelisation of sugar. the development of caramel also helps to prevent crystalisation of sugar in the brittles because it is non crystalline.

Some brittles and groundnut chikkis are made merely by melting and caramelizing sucrose. Soda is sometimes a constituent of brittles and is added after cooking is completed. It neutralizes acid decomposition products and forms carbon dioxide gas, which gives the candy a porous texture. The flavor is also made milder and less bitter by the use of soda. The degree of bitterness in a brittle depends on the extent of decomposition of the sugar. Brittles include butterscotch and toffee.

Caramels:

Caramels are firm non crystalline candies containing large amounts of interfering substances. These are cooked to temperatures between those for crystalline candies and those for hard brittle candies. The added substances that interfere with crystallization are usually butter or margarine and viscous corn syrup, molasses which contain glucose, fructose and invert sugar. corn syrup also contains dextrins which does not crystallize.

13.6 SUMMARY:

Sugars are the building blocks of carbohydrates. The most common sugars found in foods are single sugars called monosaccharides. They play a significant role in moisture absorption. Sugars are hygroscopic. Among sugars fructose is more hygroscopic. Cakes made with honey, molasses remain moist for a long time. Sugar solutions are boiled and treated to produce either crystalline or non crystalline candies. Crystalline candies are usually soft. Non crystalline candies are sometimes called amorphous which mean "without form". In their preparation, by using various procedures, crystallization of sugar is prevented. Non crystalline candies may be chewy, such as caramels or hard such as butter scotch, toffees and brittles.

13.7 TECHNICAL TERMS:

Sugars, candies, Mollasses, crystallization, brittles

13.8 SELF ASSESSMENT QUESTIONS:

1) Write about types of sugars?
2) Discuss about sugar syrups?
3) Describe in detail about types of crystallization?

13.9 REFERENCE BOOKS:

1) Food Science 7th Edition, B. Srilakshmi.

Dr. P. Kiranmayi

LESSON-14

SUGAR COOKERY

OBJECTIVES:

After going through this lesson students will understand:

- Stages of sugar cookery
- Process of crystallization.
- Factors affecting the size of crystals formed

STRUCTURE:

14.1 INTRODUCTION:

Sweeteners are used in food since ancient times, maybe beginning with the discovery of honey. Desire for sweet taste is inherent in every individual. Sugar and jiggery are used in beverages and other foods to increase palatability. India produced 192 lakh tones of sugar in the year 2005-06. It is expected to produce 230 lakh tones for the year 2006-07. Molasses, which contains the natural ash of the plant juices from which it is made, furnishes some nutrients other than carbohydrate such as a small amount of calcium and iron.

14.2 PROPERTIES OF SUGARS:

14.2.1 Solubility:

In the natural state of foods, sugars are in solution. Crystallization of sugar occurs from a sufficiently concentrated sugar solution, and use of this is made in the commercial production of sugar from sugarcane and beets. The most soluble sugar is fructose, followed by sucrose and lactose. The sugar that is the most soluble such as fructose is most difficult to crystallize than that the least-soluble sugar, lactose.

14.2.2 Absorption of Moisture:

Sugars are rehygroscopic. Compared to other sugars, fructose is more hygroscopic. Cakes made with honey, molasses remain moist for a long time.

14.2.3 Fermentation:

Most sugars, except lactose, may be fermented by yeasts to produce carbon dioxide gas and alcohol. This is an important reaction in making bread and other baked products. The carbon dioxide leavens the product and the alcohol volatilizes during baking. Acid hydrolysis: Sucrose is easily hydrolysed by acid but maltose and lactose are slowly acted on. The end products of sucrose hydrolysis are a mixture of glucose and fructose. This mixture is commonly called invett sugar. The monosaccharides are not appreciabily affected by acids. Heat accelerates the action of acid.

14.2.4 Enzyme Hydrolysis:

The enzyme sucrose also called invertase is used in the candy industry to hydrolyse some of the sucrose in cream fondant to fructose and glucose. This is done to produce soft, semifluid centres in chocolates. The enzyme is commonly added to the fondant layer around the fruit in chocolate coated cherries.

14.2.5 Melting Point and Decomposition By Heat:

Caramelisation:

With the application of sufficient dry heat, sugar melts or changes to a liquid state. Heating beyond the melting point brings about a number of decompositional changes. As sucrose melts around 160^{o}c, a clear liquid forms that gradually changes to a brown colour with continued heating. At about 170^{o} c, caramelisation occurs with the development of characteristic caramel flavor along with the brown colour.

Caramelisation is a complex reaction, involving the removal of water and eventual polymerization, Caramel has a pungent taste, is often bitter, is much less sweeter than the original sugar from which it is produced, and is non-crystalline. It is soluble in water. Fructose caramelizes at 110^{o} c, and maltose caramelizes at about 180^{o}c, galactose at 170^{o}c .

Decomposition by Alkalies:

The monosaccharides are markedly decomposed by alkalies and flavor may become strong and bitter. Sucrose is least affected by alkalies. Sweetness: Of the sugars, lactose is the least sweet, followed by maltose, galactose, glucose and sucrose with fructose being the most sweet. A maximum sweetness from fructose is most likely to be achievement when it is used slightly with acid, cold foods and in beverages.

14.3 STAGES OF SUGAR COOKERY:

Testing the doneness of sugar mixtures by measuring the temperature of the boiling solution is a method of estimating the concentration of sugar in the mixture. The final concentration of sugar is related, in general to the consistency of the product when it is completely prepared, the more concentrated the sugar solution, the firmer the consistency of the finished product (Table 1)

TABLE 1: STAGES OF SUGAR COOKERY

Product	^{o}C	^{o}F	Doneness	Descriptive of Test
Syrup (Gulab Jamun, Jaleby)	110-112	230-234	Thread	Syrup spins a 2 inch thread between thumb and first finger
Barfi, Fondant, Fudge	112-115	234-240	Soft ball	Syrup when dropped in cold water forms ball that flattens on removal from water
Boondi Laddoo	118-120	244-248	Firm ball	Syrup when dropped into very cold water, forms a ball that does not flattens on removal from water
Divinity Marshmallows	121-130	250-256	Hard ball	Syrup when dropped into very cold water, forms a ball that is hard enough to hold its shape
Butter scotch Toffies Athirasan	132-143	270-290	Soft crack	Syrup when dropped into very cold water, threads that are hard but not brittle
Brittle Glace Chikki	149-154	300-310	Hard crack	Syrup when dropped into very cold water, threads that are hard and brittle
Barley sugar	160	320	Clear liquid	Sugar liquefies
Caramel (Peanut brittle)	170	338	Brown liquid	Liquid becomes brown

Source: Manay Shakunthala.N and Shadaksharaswamy.M., 2001, Foods-Facts and Principles, New Age International Publishers, New Delhi.

14.4 CRYSTALLIZATION:

A crystal is composed of closely-packed molecules arranged in a pattern. Crystallization occurs only if the solution is supersaturated. The size of the crystals produced will depend on the rate of the formation of nuclei about which the crystals grow and the rate of growth of crystals around the nuclei. If only one or two nuclei are formed, the size of the crystals produced will be large but if the rate of formation of nuclei is very rapid, many small crystals will form. Both the rate of crystallization and the rate of nuclei formation are modified by many factors.

Microscopic Examination or Crystals:

Place a drop of turpentine on a microscope slide and add a very small grain of the candy Place a cover slip on top and move it around to make a very thin layer of the candy crystals. View under the microscope and compare the size of crystals.

Seeding:

The crystals of the same material are added to start the process of crystallization is known as seeding. The added crystals act as nuclei for crystal growth. Whether the amount of crystals added is large and the size of the crystals small or the amount of material added is small, the nuclei formed are less in number and the crystals formed are large.

14.5 FACTORS AFFECTING THE SIZE OF CRYSTALS FORMED:

14.5.1Nature of the Crystallizing Substances:

Some sugars like glucose do not have the ability to produce very large crystals, rather they produce nuclei rapidly. Thus formation of many small crystals take place probably because it causes the breaking of many nuclei from crystals already formed.

14.5.2 Concentration of the Solution:

Fairly large amounts of sugar dissolve easily in water. Higher the temperature of water, greater the amount of sugar that will dissolve in it. Maltose and Glucose are less soluble than sucrose. Hence, when syrups containing a large proportion of these sugars are used, more water must be added to dissolve them. The right conditions for rapid crystallization is to have the syrup to heat up to the right temperature or adjust to the right concentration. The lower the temperature the smaller the size of the crystals. Gulab jamun and jalebi syrups are not supersaturated solutions hence do not crystallize.

14.5.3Agitation or Stirring:

Agitation favors the formation of finer crystals that are produced spontaneously. Stirring brings the supersaturated solution in contact with each crystal. It is important to stir crystalline candy not only until crystallization starts, but until it is complete.

14.5.4 Impurities:

Impurities that may be deposited on the crystals reduce the growth of the crystals. The presence of glucose interferes with the crystallization of sucrose. Another way an impurity may interfere with crystallization is by coating the crystals. The use of fat, flour, milk, coconut, nuts, interfere with the crystal formation. For example, in making mysore pak, flour and fat are added which interfere with crystallization.

14.5.5 Addition of Acid:

An acid ingredient like cream of tartar, lemon juice or vinegar may be added to hasten the inversion of sucrose to glucose and fructose. For example, addition of citric acid and jams and jellies prevent crystallization. In sweet pickles when mango is used crystallization of prevented. Boiled sugar solutions may be treated to produce either crystalline or non-crystalline candies. Crystalline candies are generally soft.

If properly made, they are so smooth and creamy that the tiny sugar crystals that make up their microscopic structure cannot be felt on the tongue. The principal crystalline candies are fondant, mysore pak and coconut burfi. Non-crystalline candies are sometimes called amorphous which means "without form". In their preparation, by use of various techniques, crystallization of sugar is prevented. Noncrystalline candies may be chewy, such as caramels or hard such as butter scotch, toffees and brittles.

14.5.6 Degree of Inversion:

Sweets containing high concentrations of sugar that may be crystallize either during preparation or on storage. This change is desirable for certain products like fondant and fudge. When a sugar solution is heated certain amount of sucrose breaks down in to “invert sugar”. This inhibits sucrose crystallization and increases the overall concentration of sugars in the mixture. To control the amount of inversion, some ingredients like cream of tartar or citric acid may be added. These ingredients accelerate the breakdown of sucrose into invert sugar.

14.6 CRYSTALLINE CANDIES AND NON CRYSTALLIZED CANDIES:

Sugar candies are divided in to two groups. Crystalline and amorphous or non crystalline candies. Crystalline candies are not as hard as crystals of the mineral variety, but derive their name and their texture from their microscopically organized sugar structure, fromed through a process of crystallization which makes them easy to bite or cut. Fudge, creams, and a disorganized crystalline structure. They usually have higher sugar concentrations, and the texture may be chewy, hard or brittle. Hard candies, such as lollipops, caramels, nut brittles and toffees are all examples of non crystalline candies.

Preparation of Crystalline and Non Crystalline Candies:

Making of candy is an exact science and art, its success largely dependant on the knowledge of the science of sugar crystallization and timing. The preparation of soft, creamy and smooth textured crystalline candy is to develop numerous very fine nuclei in the sugar syrup solution. They are formed by

- Controlling the form and content of the sugar
- Controlling the temperature
- Stirring properly

As the solution cools, the sugar crystallizes into the proper size. If the nuclei appear slowly in the syrup solution, there is more time for the sugar molecules to aggregate around the nuclei and form large crystals.

Commercially, candies are often divided into three groups, according to the amount of sugar they contain: 100% sugar (or nearly so), such as hard candies or creams, 95% sugar or more, with up to 5% other ingredients, such as marshmallows or nougats, and 75 to 95% sugar, with 5 to 25% other ingredients, such as fudge or caramels. Each of these three groups contains both crystalline (grained) and amorphous (ungrained) candies.

Commercially, candies are divided into 3 groups, as per the amount of sugar contain

- 100% sugar, such as hard candies or creams
- 95% sugar or more, with up to 5% other ingredients, such as marshmallows
- 75% to 95% sugar, with 5 to 25% other ingredients, such as fudge or caramels.

Each of these three groups contains both crystalline and non crystalline candies

14.6.1 Crystalline Candies: Fondant is the soft smooth candy that results from the cooking of a sucrose solution to a certain temperature, after which the solution is cooled and beaten until crystallization occurs. Addition of acid temperature, after which the solution is cooled and beaten until crystallization occurs. Addition of acid hastens inversion and use of milk or creams as the liquid, enhances the creamy nature of fondant.

Fondant: As crystalline candy stands after crystallization is complete, it becomes somewhat more moist and smooth and knead easily, because some of the very small crystals dissolve in the syrup. Changes that occur during the initial period of storage are called ripening. Absorbed substances that interfere with crystallization aid in retarding the growth of crystals during storage. Fondants are used in making mints. Fondants are used in confectioneries for numerous purposes. Softened fondant is used in coating fruit and nut mixtures that are moulded and sliced.

Fudge: The principles of making fudge do not differ from those of making fondant. Usually, the butter or margarine, the fat of chocolate and the milk furnish the substances that interfere

with crystallization. The presence of substances that interfere with crystallization of sucrose in fondant and other candies is desirable, but at an optimum level. Glucose, corn syrup or invert sugar either added directly or formed by acid hydrolysis affect crystallization because they make the sugar solution more soluble and therefore, decrease the ease of crystal formation. Other substances including fats from milk, cream, butter, margarine and chocolate and proteins from milk and egg white do not themselves crystallize. They physically interfere with the process of crystallization, retarding the growth of crystals. All these interfering substances aid in fine crystal formation and smooth texture in crystalline candies

The temperature at which crystallization occurs affect the size of crystals, primarily because it affects the rate of crystallization. In general, the higher the temperature at which crystallization occurs, the faster the rate of crystallization and the more difficult is to keep the crystals separated, resulting in larger crystals. Cooling the mixture to about 40^0C before starting to beat it favours the formation of more nuclei and finer crystals. The viscosity of a solution is also greater at lower temperatures. High viscosity is a further aid in the production of fine crystals because it retards crystallization. Too low a temperature may also hinder the formation of many nuclei.

14.6.2 Non Crystalline Candies:

Sugar does not crystallize in non crystalline candies. The crystallization is prevented by cooking at very high temperature so that the finished product hardens quickly before the crystals have a chance to form, adding such large amounts of interfering substances that the crystals cannot form or combining these methods.

Brittles: Brittles are cooked to temperatures that are high enough to produce a hard, brittle candy that solidifies before it has a chance to crystallize. The brown colour and characteristic flavor of brittles result from non enzymatic browning reactions, probably both the millard type and the caramelisation of sugar. the development of caramel also helps to prevent crystalisation of sugar in the brittles because it is non crystalline.

Some brittles and groundnut chikkis are made merely by melting and caramelizing sucrose. Soda is sometimes a constituent of brittles and is added after cooking is completed. It neutralizes acid decomposition products and forms carbon dioxide gas, which gives the candy a porous texture. The flavor is also made milder and less bitter by the use of soda. The degree of bitterness in a brittle depends on the extent of decomposition of the sugar. Brittles include butterscotch and toffee.

Caramels: Caramels are firm non crystalline candies containing large amounts of interfering substances. These are cooked to temperatures between those for crystalline candies and those for hard brittle candies. The added substances that interfere with crystallization are usually butter or margarine and viscous corn syrup, molasses which contain glucose, fructose and invert sugar. corn syrup also contains dextrins which does not crystallize.

14.7 SUMMARY:

Sweeteners are used in food since ancient times, maybe beginning with the discovery of honey. Desire for sweet taste is inherent in every individual. Sugar and jiggery are used in beverages and other foods to increase palatability.

14.8 TECHNICAL TERMS:

Solubility, Hydrolysis, Melting point, Agitation

14.9 SELF ASSESSMENT QUESTIONS:

1) Explain the different stages of sugar cooker?
2) How does Crystallization of sugar take place? Explain the factors affecting crystallization?

14.10 REFERENCE BOOKS:

1) Food Science (Fifth Edition)-B. Srilakshmi (2009).
2) Foods-Facts and Principles-N.Shakuntala Manay & M.Shadaksharaswamy (2001).
3) F01FS Food Science; F01FS38 Factors Affecting Crystallization, Crystallized & on Crystallized Candies- Dr. Munira Husain.

Dr. P. Kiranmayi

LESSON-15

CONFECTIONERY

OBJECTIVES:

After going through this lesson students will understand:

- Know the types of confectionery.
- Know the types of raw materials and their role.
- Know about the Indian confectionery.

STRUCTURE:

15.1 INTRODUCTION:

Confectionery is associated to the food items that are rich in sugar and often referred to as confection. It refers to the art of creating sugar based dessert forms or subtleties often with pastillage. From the old French confection, origin of lating from conficere to "put together". The confectionery industry is also includes specialized training schools and extensive historical records. Traditional confectionery goes back to ancient times and continued to be eaten through the middle ages into the modern era. Confections include sweet foods, sweetmeats, digestive aids that are sweet, elaborate creations and something amusing and frivolous.

15.2 TYPES OF CONFECTIONARY:

Confectionery is a broad term encompassing a wide range of sweet treats. Here's a breakdown of the main types:

15.2.1 Sugar Confectionery

- Hard Candy: These are cooked to a high temperature, resulting in a hard, brittle texture. Examples include lollipops, candy canes, and boiled sweets.
- Chewy Candy: These have a softer, more pliable texture due to different cooking methods or added ingredients like gelatin. Examples include caramels, toffees, and gummies.
- Jellies and Gummies: Made with gelatin or pectin, these candies have a soft, chewy, and often translucent texture. Examples include gummy bears, jelly beans, and Turkish delight.
- Fondant: A smooth, creamy sugar paste used for decorating cakes and creating delicate candies.
- Marshmallows: These soft, airy candies are made from sugar, gelatin, and air whipped together.
- Licorice: Made from the extract of the licorice root, this candy has a distinctive flavor and chewy texture.

15.2.2 Chocolate Confectionery:

- Chocolate Bars: Solid chocolate in various shapes and sizes, often with added ingredients like nuts or caramel.
- Truffles: Chocolate spheres with a creamy filling, often coated in cocoa powder or chocolate shavings.
- Chocolate-covered treats: Fruits, nuts, or other candies coated in chocolate.
- Pralines: Chocolates with a creamy filling, often with nuts.

15.2.3. Bakers' Confectionery:

- Cakes: Sweet baked goods made with flour, sugar, and other ingredients.
- Pastries: Flaky or sweet baked goods, such as croissants, doughnuts, and scones.
- Cookies: Small, flat baked goods, often with a variety of flavors and textures.

15.2.4 Other Confectionery:

- Candied Nuts: Nuts coated in sugar and often roasted.
- Nougat: A sweet treat made with sugar, honey, and nuts, often with a chewy texture.
- Marzipan: A sweet paste made from almonds and sugar, often molded into shapes.

This is not an exhaustive list, but it covers the major categories of confectionery. Within each category, there is a vast array of flavors, textures, and forms, making the world of confectionery a sweet and exciting place to explore.

15.3 RAW MATERIALS:

Raw materials include the fundamental components used in the production of various food and beverage products. These components form the backbone of every food and beverage product, directly affect the flavor. Quality and consumer appeal. Over time, the concept of raw materials has evolved in the food and beverage industry, with increasing emphasis place on the sourcing of high quality, sustainable ingredients.

15.3.1 Role of Raw Materials:

The main raw materials for the production of sweets and savoury products are flour, sugar, fats, milk and egg products. In addition, nuts, baking powder, aromatic substances, food colours, fruits and gelling agents like gelatin, agar, fur collar etc are used.

Flours:

It is the finely ground meal of wheat and is one of the most important ingredients used in bakery products. Therefore, flour quality has a major influence on the quality of the finished baked products. Flour is important because

- Flour acts as a binding agent and an absorbing agent.
- It affects the keeping quality of products
- It is important to the flavor of products
- It adds nutritional value to the baked product.

Rice:

Broken rice and ground rice can be used as ingredients in expanded or puffed snack products. Sugar coated puffed rice is used as breakfast cereal by children.

Besan Flour:

Besan is a product obtained by grinding, drying and cuticle Bengal gram. Snacks made of Bengal gram flour are widely consumed in India. Eg: Mysore pak, Namkeen

Salt:

Salt is an indispensable flavouring for all snacks. In many varieties of these foods, it is the predominant flavor note. In general, salt is used as an ingredient that is distributed throughout the snack. This ensures a quickly sensed saltiness that is a primary determinant of consumer acceptability.

Milk:

The milk solids have a binding effect on the flour proteins, creating a toughening effect. Milk also contains lactose which helps to regulate crust colour. They improve the flavor and are important moisture retaining agents. Milk is concentrated to make khoa, which is then mixed with sugar and other ingredients to make different types of sweets like peda, burfi etc. milk is also used to make curd which could further be hung to remove whey to prepare channa. Channa is used for making different types of sweets like gluab jamun, ras malai etc.

Sweetening Agents:

Jiggery:

It is prepared from sugarcane and also from palmyra, date palm and coconut. The harvested sugarcane is crushed to obtain juice. The sugarcane juice obtained is freed from fine suspended impurities and boiled in open pans. Jiggery has a light colour, good flavor, hardness and crystalline structure with good keeping quality. It contains about 65-85% sucrose, 1-15% of inverted sugar and 2.5% ash. Jiggery is used in the preparation of non crystalline candies and a variety of sweets.

Sugar:

It is manufactured from sugarcane juice in three different forms, raw sugar, refined sugar and white sugar.

Yeast:

Yeast is used for fermentation and leavening agent. The two types of yeast are compressed yeast and dry yeast. The best storing temperature for yeast is 300-450^{o}F. When yeast is mixed with flour into dough, the yeast exhibits its growth and multiplication. This growth produces the carbon dioxide, that forms the small bubbles, rising of dough is observed. Addition of yeast increases the volume and improves the grain, texture and flavor.

Vegetable Oil and Fats:

Oils are extracted from the seeds or other parts of fruits sunflower and corn oil are used in the preparation of certain types of flour confectionary. Ghee or ground nut oil is used to fry gulab jamun balls, and savoury products like makeen, chips and pakoras. Coconut oil is also used for spraying finished snack pieces and it often serves as the carrier for powdered flavours applied to corn curls.

Nuts:

Nuts are very important ingredient in the preparation of sweets like gulab jamun, rasmalis cakes and pastries. Savoury products such as roasted peanuts, roasted cashews and numkeens also use a wide variety of nuts. The commonly used nuts in sweet and savoury products are peanuts, almonds, cashews, walnuts, pistachil, raisins.

Seasoning and Flavourings:

Many ingredients are used to enhance the taste of foods. These ingredients can be used to provide both seasoning and flavouring. Before adding any seasoning or flavouring to the product, one must understand the quantity and particle size of the seasoning to be sprinkled.

Seasoning means to bring out or intensify the natural flavor of the food without changing it. Seasonings are usually added near the end of the cooking period. The most common seasonings are salt, pepper, lemon juice. The function of seasonings is to enhance the flavours of the original ingredients.

Flavouring refers to something that modifies the original flavor of the food. Flavouring can be used to contrast a taste such a adding liqueur to a dessert where both the unique flavor in which it is difficult to discern what the separate flavourings are. Spice blends used in pumpking pies are a good example of this.

Spices:

Spices are aromatic substances from the dried parts of plants such as the roots, shoots fruits, bark and leaves. They are sold as seeds, blends of spices, whole or ground spices and seasonings. The aromatic substances that give a spice its particular aroma and flavor are essential oils. The flavor of the essential oil or flavouring compound will vary depending on the quality and freshness of the spice

Food Colourings:

To give various colours to confectionery products and separate semi finished products, several dyes are used. Food dyes are divided into natural derived from plant or animal objects of natural origin and synthetic, derived from organic synthesis products. The most common natural dyes used in the sweet and savoury industry are carmine and turmeric. The most common synthetic dyes are indigo carmine and tartrazine.

15.4 INDIAN CONFECTIONARY:

Confectionery is the art of making confections those include food items that are rich in sugar and carbohydrates. In general confectionery is classified in to four major groups.

They are:

15.4.1 Sugar Confectionery:

It includes products using mainly sugar such as boiled sweets, fondants, fudge, jellies, toffees, etc. based on the structural geometry, sugar confectionery is categorized into two groups: amorphous sugar confectionery, include hard, chewy, homogenous and non crystalline products. Eg: hard boiled candy, caramels, toffee, taffy, brittles, gums and jellies. Crystalline sugar confectionery are described by crystal structure. It includes chocolate, fondant, nougats, fudge, marshmallows, etc.

The basic principles include; balance the recipe , prepare the ingredients mix together the , ingredient , boil the mixture until the desired temperature has been reached.

Sweets containing high levels of sucrose may crystallize either during preparation or on storage. When a sugar solution is heated, a certain percentage of sucrose breaks down to form 'invert sugar'. The invert sugar inhibits sucrose crystallization and enhances the overall concentration of sugars in the mixture. This natural process of inversion, however, makes it difficult to accurately assess the degree of invert sugar that will be produced. Variations in boiling temperature can make a difference between a sticky, cloudy sweet or a dry, clear sweet. An accurate way of measuring the temperature is to use a sugar thermometer. Other tests can be used to assess the temperature (for example, toffee temperatures can be estimated by removing a sample, cooling it in water, and examining it when cold). The temperatures are known by distinctive names such as 'soft ball', 'hard ball' etc., all of which refer to the consistency of the cold toffee.

In case of sweet Fondants, temperature range for boiling 116-121^{0}C. Fudge Caramels and regular toffee Hard toffee, Hard-boiled sweets Moisture Content 116^{0}C, 118-132 ^{0}C, 146-154 ^{0}C, 149-166 ^{0}C.

Moisture Control:

The water left in the sweet will influence its storage behavior and determine whether the product will dry out, or pick up some moisture. For sweets which contain more than 4 % moisture, the sucrose will crystallize on storage. The surface of the sweet will absorb water, the sucrose solution will subsequently weaken, and crystallization will occur at the surface, later spreading throughout the sweet.

Added Ingredients:

The addition of certain ingredients can affect the temperature of boiling. For example, if liquid milk is used in the production of toffees, the moisture content of the mixture immediately increases, and will therefore require a longer boiling time in order to reach the desired moisture content. Added ingredients effect the shelf-life of the sweet. Toffees, caramels, and fudges, which contain milk-solids and fat, have a higher viscosity, which controls crystallization. in contrast, the use of fats may make the sweet prone to rancidity, and therefore the shelf life will be shortened.

15.4.2 Chocolate Confectionery:

It includes mainly cocoa, chocolate and chocolate products. Sugar confectionery coated with chocolate is also included in it.

15.4.3 Flour Confectionery:

It includes baked products such as cakes, biscuits, cream rolls, etc. Traditional Indian cereal and legume flour based sweets such as mysorepak, soanpapdi, badushah, jalebi, etc.

Gulab Jamun:

It is a popular sweet prepared in all parts of india. There are large variations in the sensory quality of gluabjamun. The product shoud have a brown colour, smooth and spherical shape, soft and slightly spongy body free from both lumps and hard central core, uniform granular texture, mildly cooked and oily flavor free from the doughy feel and fully succulent with sugar syrup. It shall have optimum sweetness. Basically gulab jamun is prepared by the raditional method and the large scale mechanized method.

Stages of Sugar Cookery:

Preparation of sugar syrups and caramel always begins with heating and melting ordinary granulated sugar and recrystallizing the syrup according to the need. During the heating process, dissolve the sugar into syrup. As the temperature reached maximum level the syrup begins to thicken. As the temperature continues to rise and the water evaporates, the sugar begins to caramelize and turn a darker colour. As long as, there is a lot of water in the syrup mixture the temperature will not raise much above the boiling point. As the water begins to evaporate the temperature of the mixture also begins to rise. At 160^0 C, there is no water left, the sugar is melted and begins to caramelize and the sweetness starts to decrease. The hotter the caramel gets the darker it becomes, and the deeper and less sweet the flavor becomes. Formally the sugar syrup undergoes six distinct stages or forms when it has been boiling from room temperature to the maximum temperature of 160^0 C (Table 1).

TABLE 15.1: STAGES OF SUGAR COOKING

	^{0}F	^{0}C	Concentration	
Thread	223-234	106-112	80%	It is a test of how hot sugar syrup is, and of how much water is left in it. At this point of heating , the sugar concentration in the syrup is 80%. The syrup will form a loose thin thread. Used for making sugar syrups.
Soft ball	224-240	112-115	85%	At this point of heating, the sugar concentration in the syrup is 85%. To test this stage a small amount of the sugar syrup could be dropped from a spoon into a cup of cold water. If the stage has been reached, the syrup will form a soft, sticky ball that can be flattened when remove from the water. Used for caramels, fudge, pralines, fondant, and butter creams.

Firm ball	242-248	116-120	87%	At this point of heating the sugar concentration in the syrup is 87%. To test this stage a small amount of the sugar syrup could be dropped from a spoon into a cup of cold water. When taken out from the water, the syrup will form a firm but pliable, stick ball that holds its shape briefly. Used for caramels, butter creams, nougat, marshmallows, gummies, and toffees.
Hard ball	250-266	122-130	92%	At this point of heating, the sugar concentration in the syrup is 92%. When a small amount of sugar syrup from a spoon is dropped in to a cup of cold water the syrup will form a firm ball (clump). When taken out from the water, the syrup will form a hard, sticky ball that holds is shape. Used for caramels, nougat, divinity and toffees.
Soft crack	270-290	132-143	95%	At this point of heating, the sugar concentration in the syrup is 95%. The syrup will form strands that are firm yet pliable. Used for butterscotch, firm nougat and taffy.
Hard crack	295-310	146-155	99%	At this point of heating, the sugar concentration in the syrup is 99% The syrup will form threads that are brittle and break easily. Used for brittles, toffees, glazed fruit, hard candy, pulled poured and spun sugar.
Clear liqud	320^0F	160^0C	100%	At this temperature, all the water has boiled away. The remaining sugar is liquid and light amber.
Brown liquid caramel	320-360	160-185	100%	The syrup will become transparent and will change colour, ranging from light golden brown to dark amber. Used for pralines, brittles, caramel coated moulds, and nougatine.
Burnt sugar	350^0F	177 ^{0}C	100%	The sugar begins to burn and develops a bitter, burnt taste

Laddoo:

It is a ball shaped sweet prepared with besan, rava or atta. During its preparation combine four with sugar and other flavourings and cooking in ghee followed by molding into a ball shape.

15.4.4 Milk Confectionery:

It includes mainly Indian traditional milk-based sweets such as *burfi*, *peda*, *rasogolla* etc.

Khoa Burfi:

Generally khoa is prepared by different methods depending on the location and quality of milk available for conversion. It is prepared by traditional method, improved batch method, mechanized method and use of membrane technology (Fig.15.1)

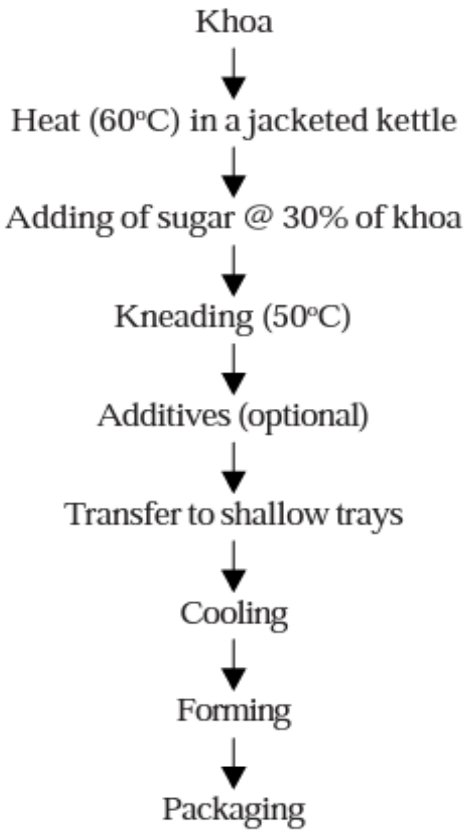

Fig. 15.1 Flow Chart for Preparation of Burfi

15.5 SUMMERY:

Confectionery is associated to the food items that are rich in sugar and often referred to as confection. Raw materials include the fundamental components used in the production of various food and beverage products. These components form the backbone of every food and beverage product, directly affect the flavor. sugar confectionery is categorized into two groups: amorphous sugar confectionery, include hard, chewy, homogenous and non crystalline products. Eg: hard boiled candy, caramels, toffee, taffy, brittles, gums and jellies. Milk confectionery includes mainly Indian conventional milk-based sweets such as burfi, peda, rasogolla etc.

15.6 TECHNICAL TERMS:

Confections, raw materials, sugar cookery, fondant.

15.7 SELF ASSESSMENT QUESTIONS:

1) Write an account on confection
2) Explain in detail about role of raw materials
3) Discuss in detail about Indian confectionary

15.8 REFERENCE BOOKS:

1) FICSI participant handbook, ID: FIC/Q8504 Version 1.0 NSQF level:3 Traditional sweets and Savoury maker
2) Bakery and Confectionery Technology Paper No.9, Module no 22. Title: Role of ingredients used in confectionery industry.
3) http://ecoursesonline.iasri.res.in/mod/resource/view.php?id=5878
4) Paper No. 09 Paper Title: Bakery and Confectionery Technology Module No. 35 Module Title: Overview of popular Indian flour confections
5) chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.baf.com.fj/wp-content/uploads/2016/09/Confectionery.pdf

Dr. P. Kiranmayi

LESSON-16

FATS AND OILS

OBJECTIVES:

After going through this lesson students will understand:

- Composition of fats and oils
- Functional properties of fats
- Rancidity

STRUCTURE:

16.1 INTRODUCTION:

Naturally fat is present in different types of foods. This fat is referred as invisible fat. Invisible fat containing foods in appreciable amounts include meat, poultry, fish, dairy

products, eggs, nuts and seeds. Visible fats are present in lard, cooking oils, salad oils, margarine and butter.

Fats exhibit a variety of roles in both preparation of food and nutrition. In common usage, fats that have a comparatively high melting point and are solid at room temperature are called fats, whereas those that have lower melting points and are liquid at room temperature are called oils.

16.2 SOURCES:

The main sources of fats and oils are animal, vegetable and marine origin. Vegetable facts are generally including the solid fat and the oils are peanut oil, olive oil, sun flower oil, cotton seed oil, coconut oil, soybean oil etc.

Animal and Plant Sources:

Butter:

In butter preparation, initially the cream is subjected to pasteurization to inactivate the enzyme lipase and to destroy the various microorganisms. Starter culture (culture of bacteria) is added to the cream for lactic acid production and flavor change. The culture cream is allowed to ripen for few hours and churned.

Butter is separated more or less completely from the milk constituents by churning. During churning or agitation, the mechanical rupture of the protein film that surrounds each of the fat globules in cream allows the fat globules to join together. Formation of butter is an example of the breakdown of oil in water emulsion by agitation. The volatile fatty acids and other substances called diacetyl, formed by the action of microorganisms impart flavor to the butter.

Lard:

Through the rendering process lard is prepared. In this process adipose tissues of hog are cut in to small pieces and heated, with or without the addition of water, to remove fat from the cells. The quality of the lard depends on availability of adipose tissue in the animal and method of heating. To delay the rancidity, antioxidant is added. Some times to improve the baking performance, lard may be bleached, hydrogenated, deodourised and emulsifier added. To enhance the plasticity and creaming qualities, inter esterification process is essential.

Margarine:

For the production of margarine, soybean and cotton seed oils are refined and partially hydrogenated to obtain desired consistency. Margarine is also made from optional fat ingredients agitated with cultured pasteurized skim milk or whey. Vitamin A and D are also added to margarine to improve its nutritive value. The flavouring agents, emulsifiers, artificial colouring agents, salt, citric acid and sodium benzoate as preservative (0.1%) are added to the margarine.

Cotton Seed Oil:

It is used as shortening, consumed as a salad or cooking oil. This oil has a neutral flavor that does not mask the flavor of other products.

Ground Nut Oil:

Compared to other oils, ground nut oil is produced more in India extensively used in cooking and as a salad oil. The major commercial uses of are in the preparation of soap, vanaspathi, margarine, pharmaceutical preparations etc. the melting point of coconut oil is similar to the chocolate and therefore useful in confectionery and cookie fillings. Coconut oil is used in cooking like banana chips to the typical flavor.

Olive Oil:

Olive oil consists of 55-83% monounsaturated fatty acids, 8-14% of saturated fatty acids, 4-24% of polyunsaturated fatty acids. Other components are vitamin E, A and phenols. These compounds show beneficial effects on health (coronoary heart disease and cancer).

Rice Bran Oil:

Rice bran oil contains unsaponifiable components such as tocotrienols and oryzanol a high amounts. These are good antioxidants. This oil is rich in vitamin E which gives oxidative stability to the oil. In addition it has higher cholesterol lowering effect than other oils. The shelf life of this oil is high when compared to other oils. Foods deep fried in rice bran oil showed that this oil is less absorbed in fried foods when compared to food fried in ground nut oil.

Palm Oil:

It is produced from the fruit of the *Elaeis guineensis* palm. It is used as cooking oil in margarines and shortening and as an ingredient in fat blends and huge range of food products. Food manufacturers choose palm oil because it requires little or no hydrogenation and extends the shelf of products. Palm oil is superior to corn, soyabeen, rapeseed and ground nut oil in oxidative stability. It contains equal proportions of saturated fatty acids and unsaturated fatty acids. It has 44% palmatic acid and 5% stearic acid; 39% mono undaturated fatty acids and 10% polyunsaturated fatty acids. Tocotrienols in this oil reduce the cholesterol synthesis in liver.

16.3 COMPOSITION:

Most oil bearing plants store their fat as triacylglycerols in the seed endosperm (e.g., sunflower) or the fleshy fruit mesocarp (e.g., avocado). Some like the palm store oil both in the mesocarp (palm oil) and endosperm (palm kernel oil). Seed oils vary widely in their fatty acid compositions. Seed oil that are dietary importance are generally those in which the predominant fatty acids are the common ones: palmitic;stearic;oleic and linoleic acids. The exceptions are coconut ad palm kernel oils which are unusual in containing saturated fatty acids of medium chain length (c_8-c_{14}). Only milk fat contain appreciable sources of these acids.

Seed oils can also be important sources of carotemids, tocopherols and plant sterols such as β-sitosterol although the latter is not absorbed from the human gut.

They are concentrated source of energy. Wight for weight, they furnish 2.25 times more energy thatn protins and carbohydrates. All oils and fats except butter give 900 kilocalories per hundred grams. Butter gives 729 calories as it contains more moisture.

- They reduce bulk in the diet.
- They are excellent source of fat soluble vitamins A, D, E and K. consumption is low because it is expensive. Butter contains 15,000 I.U. of vitamin A. refined vegetable oil and hydrogenated shortenings contain little or no vitamin A, but vegetable oils are good source vitamin E.
- They play a part in the biosynthesis of several long chain fatty acids.
- They provide essential fatty acids, which are components of membranes of living cells.
- They are also used by the body to make prostaglandins involved in large variety of vital physiological functions, fish is an excellent source of eiecosa pentaenoic aicd (EPA) from which the body can make a hormone like compound called a prostaglandin. This particular prostaglandin reduces the bold clotting rate and thus the likelihood of a clot blocking the corornary arteries.

Fats are slow in leaving the stomach and hence retard digestion. This delays the pangs of hunger. There is no difference in the digestibility of different fats. They are utilized to the extent of 95-98. Digestibility is elated to melting point. Those which melt below 43^0C are slowly and less completely absorbed.

When fats contain a relatively high proportion of saturated fatty acids such as palmitic and stearic acids, they have relatively high melting points and are usually solid at room temperature. When fats contain a relatively high proportion of unsaturated fatty acids such as the monounsaturated oleic acid and polyunsaturated linoleic aicd, they have relatively low melting point and are oils at room temperature.

As the number of carbon atoms in the fatty acids increases, thus making longer chain fatty acids, the melting point also increases. Butyric acid with four carbon atoms melts at a lower temperature than does stearic acid with 18 carbon atoms. Both of these fatty acids are saturated. Butter contains a relatively large proportion of short chain fatty acids and melts at a lower temperature than does beef fat or hydrogenated shortening, which contain more long chain fatty acids.

16.4 ABSORPTION:

From the standpoint of both palatability and ease or rapidity of digestion, it is desirable to hold fat absorption by fried food to a minimum. Generally some 10% oil or fat is absorbed

but larger amounts are absorbed in some conditions where the product becomes soggy and undesirable. Among the factors that affect the amount of fat absorbed are

- The character and composition of food
- The addition of egg to fritter type batter that contains no additional no additional shortening significantly increases fat absorption. Egg yolk contains phospholipids.
- Doughnuts made from soft wheat flours absorb more fat than made from strong flours. The development of gluten by the extensive manipulation of the dough decreases fat absorption as compared with dough in which gluten has not been developed.
- Porous surfaces like bread or fermented foods absorb fat. Surface with more cracks, due to under manipulation, absorb more fat.
- Addition of sodium bicarbonate to bajji batter causes porousness in the food which absorbs oil
- Greater the surface area more absorption of fat takes place.
- If the moisture content of the material is higher, the fat absorption is also greater than the control in preparation like pooris and vadas.
- The condition of the frying fat, including the level of surfactants present. An optimum level of surfactants present. An optimum level of surfactants in the frying fat produces optimal fat absorption. With excessive amounts of surfactants, more oil is drawn into the food.

16.5 FUNCTIONAL PROPERTIES OF FATS:

Fat Improves the Texture of Foods:

Fat plays an important role in the proper development of texture in cakes, biscuits and cookies. Its function is particularly important in pastries where there is no sugar to contribute to tenderness.

16.5.1 Fat Helps in Leavening:

In making cake, leavening occurs by incorporating air into the fat during the leavening process. When the butter is hated in the oven, the small air bubbles expand and fill with stem. The greater percentage of leavening in cake comes from the steam that collects in the tiny air bubbles rather than from the air itself. Gluten in the flour forms the walls around each little bubble and during baking they act to a fairly rigid structure.

When the cake is removed from the oven and is cooled, the air in the small bubbles contracts and the steam condenses. In a well balanced recipe the process is its ability to trap air during the mixing process. So the fat is indirectly responsible for the tenderness of the

cake. The walls around each bubble are made of gluten and starch which can be very tough and hard. Fat is streaked through and serves as a lubricant so that when the cake is beaten, particles of gluten and starch slide on one another and the walls crumble. Thus, fat contributes to the volume of baked products. Though all baked products use fat, amounts used are different. Fat forms part of the foam structure of whipped cream.

16.5.2 Shortening Power of Fats:

The shortening power of certain fats makes them essential in the preparation of pastries, pie crusts, biscuits and cakes. The highly saturated fats tend to have a greater shortening power. When saturated fats are mixed into a flour mixture, fat separates the flour's starch and protein and when heated, melts in to the dough. This creates air spaces that give the finished baked product its delicate texture. These fats impart crisp and crumbly texture to baked products and to increase the plasticity, or workability of doughs. Important commercial shortenings include butter, lard, vegetable oils, processed shortenings, and margarine.

The desirable characteristics of shortenings include bland or pleasant flavour, freedom from objectionable odour, light or clear colour, a high degree of plasticity, long storage life, and good shortening power, or ability to weaken and lubricate the structure of baked products to produce tenderness. The proportion of shortening in doughs and batters varies according to the product. With breads and rolls containing about 1-2 %, cakes containing 10-20 %, and pie crusts containing over 30%. Increasing the shortening proportions increases tenderness, but very high proportions may cause cakes to fall.

16.5.3 Fat for Smoothness:

Fats have textural effects in ice creams and frozen desserts. They limit the size of water crystals and help in maintaining smooth texture. They affect the smoothness of crystalline candies through the retardation of crystallization and the gelatinization of starch in starch thickened mixtures. Fat interferes with crystallization of sugar. e.g., halwa.

Fat prevents lump formation and brings smoothness. When grains are fried initially while making pulao or upma they get coated with oil or fat and this helps in reducing lump formation and excess gelatinization and grains remain separated after completion of cooking. Fats form emulsion in mayonnaise and give smooth texture.

16.5.3 Fat for Smoothness:

Fat gives taste and flavor to the food. Some fats like ghee is used at the table to improve the flavor and to reduce pungency. Ghee and butter when used in the recipe improve the flavor. Butte is spread on bread to improve the palatability. Fat is used to enrich sauces. When butter is applied to bread, the palaltability is improved.

The ability of fats to take up or dissolve certain aromatic flavor substances is frequently used in food preparation. Onion, ginger, garlic, peppers and other flavourful foods

are cooked in oil so initially flavor can be incorporated into other foods. Aromatic fruits and other flavoured are also dissolved by fat. Colouring agents like turmeric when added to oil helps in the distribution of colour throughout the food.

16.5.4 Improves Quality of the Product:

Fat improves the quality -because fat is often emulsified with moisture in baked products, helps to retain the moisture and prevents them from drying out or going stale too quickly.

Fat also improves keeping quality by reducing the moisture content as in fried food. Fat can be used as a moisture repelling seal in fried food and preserve the quality.

16.6 RANCIDITY:

Spoilage of fats may occur on storage, particularly if the fats are highly unsaturated and the conditions of storage are conducive to chemical change in the fats. Rancidity is of two types-hydrolytic and oxidative.

16.6.1 Hydrolysis:

Hydrolysis is brought about by enzymes that decompose fats in to free fatty acids and glycerol. Butyric and caroic acids which are the volatile fatty acids predominating in butter are largely responsible for the odour and flavor of rancid butter. These acids may render butter inedible even when they are present in low concentrations. Long chain fatty acids such as stearic, palmitic and oleic acids do not usually produce a disagreeable flavor unless other changes such as oxidation also occur. Heating thoroughly to destroy the lipase enzyme that catalyses the hydrolysis of triglycerides should prevent hydrolytic rancidity. Contaminating microorganisms may also produce lipase and these can similarly be destroyed with sufficient heating.

16.6.2 Oxidation:

Only unsaturated fats and foods which have lipoxygenase are susceptible to oxidative changes. Highly hydrogenated and saturated fatty acids are relatively resistant to oxidation. Hydroperoxides that are formed, break readily producing smaller volatile substances that give the chatacteristic odours of rancid fat. The reaction is a chain reaction that is self perpetuating.

The development of rancidity is objectionable not only because of the undesirable changes in odour, flavor, colour and consistency of fat but because, it is accompanied by the inactivation of vitamin A and E. oxidative rancidity may be problem in dry foods containing only small quantities of fat, such as prepared cereals.

Fats subjected to either or both of these types of changes may contain fatty oxy and hydroxyl acids, ketones and lactones may include trimethylamine, with its fishy odour.

16.6.3 Spoilage by Microorganisms:

Some mircro organisms produce fat soluble pigments and these pigments can easily diffuse into fat and produce discolourations like yellow, red, purple and brown. The fat soluble pigment in oxidation and reduction indicatior that changes from yellow to green to blue and finally to purple as the fat becomes more oxidized by the peroxides formed by the bacteria. The pigments that are produced by various bacteria, yeast and moulds are yellow, pink and red in colour.

Bacterial species like *Pesudomans, Micrococcus, Bacillus* and *Serritia, achromobacter* and *Protues; moulds like Penicillum, Aspergillus, Cladosporium* and *Monilia* can decompose fats.

Spoilage of Salad Dressings:

Oil in salad dressings my become oxidized or hydrolysed to permit microbial growth. The types of spoilage of mayonnaise and related dressings are

- Separation of oil or water from the emulsion
- Oxidation and hydrolysis of the oils by chemical or biological action
- Growth of micro organisms to produce gas, off flavours or darkening

16.6.4 Prevention of Rancidity:

Fats can be protected against the development of rancidity by managing the conditions of storage. Storage at low temperatures prevent rancidity by reducing the autooxidation. Light rays may catlyse the oxidation of fats. Use of coloured glass containers that absorb the active rays, therefore fats can be protected from spoilage. Certain shades of green coloured bottles, wrapers and yellow transparent cellophane wrappers are efficient in preventing fat spoilage.

Vacuum packing also reduce the development of rancidity by excluding oxygen. Antioxidants like Vitamin C, beta carotene and vitamin E gives protection against rancidity. Synthetic antioxidants like butyated hydroxyanisole (BHA), butylated hydroxytoulene (BHT), tertiary butyl hydroquinone (TBHQ) and propyl gallate helps to prevent fat spoilage.

Citric acid may be used along with antioxidant as synergists. Synergist enhances the effectiveness of an antioxidant . some synergists may be effective because of their ability to bind or chelate the metals and prevent them catalyzing the oxidation process. Chelating agents are also called sequestering agents.

16.7 SUMMARY:

Fats take part in a variety of roles in both food preparation and nutrition. In regular usage, fats that have a somewhat high melting point and are solid at room temperature.

Spoilage of fats may observe on storage, especially if the fats are highly unsaturated and the conditions of storage are favorable to chemical change in the fats.

16.8 TECHNICAL TERMS:

Fats, Oils, Rancidity, Oxidation, Hydrolysis, Antioxidants, Chelating Agents.

16.9 SELF ASSESSMENT QUESTIONS:

1) Write about composition of fats and oils?
2) Discuss about various sources of fats?
3) Describe in detail about rancidity?

16.10 REFERENCE BOOKS:

1) Food Science 7th Edition, B.Srilakshmi.

Dr. P. Kiranmayi

LESSON-17

SENSORY ATTRIBUTES OF FOOD QUALITY AND ITS CHARACTERISTICS

OBJECTIVES:

After going through this lesson students will understand:

- Define sensory evaluation and apply it for different uses;
- State the role of different receptors/senses in sensory evaluation;
- Control the different factors for proper conduct of sensory evaluation.

STRUCTURE:

17.1 INTRODUCTION:

Quality in general is defined as degree of excellence and is continuous process of improvement to meet the requirements of the consumer in the present context. The food has got several quality attributes not limited to only sensory qualities; however in the present chapter quality attributes with respect to sensory aspects of food will be dealt. Any food item raw (fresh) and processed will have its characteristics qualities. The raw or fresh produces such as nuts, fruits, vegetables, grains, milk, and eggs etc., the quality attributes are decided by the type, variety, place of origin, cultivations practices, and stage of harvesting and so on so forth. While in the processed foods quality attributes are controlled by the preparation

methodology, cooking recipe, and food packing/serving type and purpose of processing either industrial scale for preservation suitable for marketable life or home scale for immediate consumption. Understanding or expression of food quality varies with individuals. A public health professional simply terms it as good quality food means the one which doesn't make people sick. While a food business operator will define it as food quality means product attributes that lead to consistent end product and manufacturing operations. The food safety /food standards and certification officials describes food quality as the one which meets the defined specifications such as viscosity, density, color, texture, etc. Whereas the consumer, the real king; needs a product tasty, safe and cost effective. Certain regulations describe that "Quality is the inherent properties of any processed product which determine the relative degree of excellence of such product and includes the effect of preparation and processing and mayor may not include the effects of packaging or added ingredients/ additives". The food quality attributes can be classified as Visible and Invisible characteristics in food science. The visible quality attributes refers to the sensory attributes of the food while the invisible or hidden quality refers to the nutritive value of the food. The hidden quality attribute include the nutritive compound such as carbohydrates, protein, fats, fibre, vitamins, minerals and as well as the non nutritive compounds such as phytates, tannins, pigments (though influence the color of the food), oxalates and certain undesirable compounds.

17.2 DEFINITION, IMPORTANCE OF SENSORY EVALUATION:

17.2.1. Definition of Sensory Evaluation:

Sensory evaluation is the scientific process of measuring, analyzing, and interpreting the characteristics of food as perceived by the human senses—sight, smell, taste, touch, and hearing. It involves the use of trained or untrained panels to assess appearance, aroma, flavor, texture, and sound of food or other products.

17.2.2. Importance of Sensory Evaluation

17.2.2.1. Quality Control and Assurance:

- Ensures consistency and quality in food products during production.
- Detects defects, deviations, or undesirable changes in sensory attributes.

17.2.2.2. Product Development:

- Helps formulate new products and improve existing ones to match consumer preferences.
- Sensory testing guides adjustments in ingredients, processing methods, and packaging.

17.2.2.3. Consumer Acceptance and Preference:

- Determines consumer satisfaction and product likability.
- Identifies the factors influencing consumer purchase decisions.

17.2.2.4. Shelf-Life Determination: Monitors sensory changes (e.g., appearance, aroma, texture) over time to evaluate freshness and shelf stability.

17.2.2.5. Marketing and Branding: Sensory characteristics help differentiate products in a competitive market. Assists in creating compelling product descriptions for advertising.

17.2.2.6. Regulatory Compliance: Certain industries require sensory evaluation to meet food safety and regulatory standards.

17.2.2.7. Cost Optimization: Helps maintain quality while exploring ways to optimize cost (e.g., replacing ingredients without compromising sensory attributes).

17.2.2.8. Assessing Consumer Complaints: Sensory testing helps address issues raised by consumers regarding product quality (e.g., off-flavors, texture issues).

17.3 SENSORY RECEPTORS AND THEIR ROLE IN SENSORY EVALUATION:

Sensory receptors are detectors (or senses), which indicate about the physical and chemical changes in our environment, Psychologists recognize 22 special senses, out of which 5 are primary senses and perceive stimuli. These senses are sight, hearing, touch, smell, and taste. Other senses include: temperature, pain, visceral, hunger, thirst, fatigue, sex (drive) and equilibrium. In human beings at least three different senses respond to specific chemical stimuli: taste, smell and common chemical or pain sense. The sense organs consist of sensory cells or group of cells, which respond to stimuli and transmit an impulse via the nervous system to the brain. Human nervous system constitute of chemical senses, somatic senses and auditory.

17.4. SENSES INCLUDE THE AROMA/SMELL, SIGHT, HEARING/SOUND, TASTE AND TOUCH/HAND FEEL

In the evaluation of food quality and overall experience, the human senses play a vital role. These senses include **aroma/smell, sight, hearing/sound, taste**, and **touch/hand feel**. Each sense contributes to how we perceive and evaluate food and beverages.

17.4.1. Taste:

Taste is one of the most fundamental senses through which humans experience food. It's not just about whether a food is pleasant or unpleasant—it’s the ultimate factor that determines its acceptability. The process by which we perceive taste is complex, involving a combination of chemical reactions, sensory input, and neural responses.

17.4.1.1. The Mechanism of Taste Perception:

Taste is primarily perceived through the tongue, but it's not confined to this one organ. The sensation we experience when we eat or drink is the result of chemical interactions between food substances and taste receptors located on our taste buds. These receptors, found

in the oral cavity and predominantly on the tongue, are specialized for detecting specific types of taste stimuli.

The tongue houses taste receptors within small structures known as **taste buds** or **gustatory calyculi**. These receptor cells interact with food molecules to send signals to the brain, where they are interpreted as different tastes. But taste doesn't work in isolation—smell (olfaction) and texture (mediated by the trigeminal nerve) are equally critical in determining the flavor we experience.

The Five Basic Tastes: Humans can detect five basic tastes:

1) **Sweet:** Typically associated with sugars and other carbohydrates, sweet taste is mostly perceived at the tip of the tongue. This preference can be seen in young children who often prefer licking a sweet candy sucker rather than chewing it.
2) **Sour:** Sour taste is primarily detected by the sides of the tongue and is mostly triggered by acids in food, such as citric acid in lemons. It's often associated with the ripeness or spoilage of food.
3) **Salt:** Salt receptors are predominantly found on the front portion of the tongue. They are most sensitive to inorganic salts, such as sodium chloride, which is essential for regulating fluid balance and maintaining cell function in the body.
4) **Bitter:** Bitter receptors are located at the back of the tongue and are highly sensitive to compounds that are often associated with toxins or poisonous substances. This heightened sensitivity helps humans avoid potentially harmful foods.
5) **Umami:** This savory taste is triggered by amino acids, primarily glutamate, which is commonly found in meats, cheeses, and fermented products. Umami plays a significant role in the flavor complexity of many dishes.

17.4.2. Aroma:

Aroma, or odor, is one of the most powerful sensory cues influencing our food experience. Often used interchangeably with terms like fragrance or smell, aroma plays a critical role in how we perceive and enjoy food. The olfactory system, responsible for detecting aromas, is highly sensitive and allows us to identify, crave, and even differentiate between complex flavors without having to see or taste the food directly.

17.4.2.1. The Mechanism of Aroma Perception:

Aroma is primarily sensed by the **olfactory system**, which includes the **olfactory glands** located in the nasal cavity. When we smell something, volatile compounds released by food-such as those from fruits, spices, or cooked dishes-travel through the air and enter our noses. These molecules then bind to olfactory receptors, triggering neural responses that are interpreted by the brain as specific scents.

17.4.2.2. Volatile compounds: the building blocks of aroma:

The aroma of food is determined by the volatile compounds it releases. These compounds vary depending on the food type, its preparation, and even its ripeness. For example:

- **Fruits:** Esters like **ethyl acetate, methyl acetate**, and **octyl acetate** are responsible for the sweet and fruity aromas found in apples, oranges, and pineapples. Terpenes such as **citral** and **linalool** provide citrus and floral notes.
- **Spices:** Spices are rich in aromatic compounds that contribute to their distinctive smells. For instance, **gingerol** and **zingiberene** from ginger, **cinnamaldehyde** from cinnamon, and **eugenol** from cloves are key contributors to the pungent, spicy, and warm aromas of Indian cuisine. The presence of **carvacrol** and **thymol** in oregano and thyme adds to the savory, herbal profile of dishes.
- **Fermentation:** During processes like fermentation, a variety of new aromatic compounds are produced. In wines, for example, compounds like **ethyl acetate** and **acetaldehyde** contribute to fruity and floral notes, while **lactic acid** in curd or pickles generates sour, tangy aromas.

17.4.2.3 Describing Aroma: Words We Use to Capture Smells:

Aroma, being highly individualistic and dependent on the volatile compounds released by a food item, can be challenging to describe. However, various terms have been developed to capture the essence of a food's aroma. These descriptors can be grouped into different categories:

- **Pleasant aromas**: Aromatic, fragrant, floral, sweet, savory, citrus, fresh, herbal.
- **Unpleasant aromas**: Rancid, rotten, musty, acrid, burnt, overcooked, tainted, sour.
- **Intensity**: Aromas can also be described in terms of their strength, such as mild, strong, pungent, light, or intense. These terms are useful for both food sensory evaluation and consumer preferences.
- **Processing-related descriptors**: Certain words like **roasted, smoky**, or **grilled a**re often used to describe aromas that result from food preparation methods. These terms reflect changes in aroma brought about by heat, which can induce the release of new compounds or alter existing ones.

17.4.2.4. Aroma and Its Role in Craving and Food Selection:

The power of aroma in food selection cannot be overstated. The smell of food can trigger strong emotional and physiological responses even before we see or taste it. For instance, the sweet aroma of a ripening mango can evoke cravings for the fruit, while the scent of freshly baked bread can stimulate hunger and anticipation. The connection between aroma and desire is deeply rooted in **cognizance**-our ability to recognize familiar scents and associate them with past experiences. This cognitive response explains why we often feel a strong urge to consume certain foods based on their smell alone.

In culinary practices, aroma is also carefully cultivated. Chefs and food scientists use aromatic compounds to enhance the sensory experience, making food more appetizing. The smell of a food item can influence our perception of its taste, creating a more immersive eating experience.

17.4.2.5. Practical Applications: The Importance of Aroma in Food Science:

In food science, the study of aroma is crucial for product development and quality control. Flavor scientists use **gas chromatography** and **mass spectrometry** to isolate and identify specific volatile compounds in food. These analytical techniques help in the formulation of food products that are consistent in aroma and flavor, ensuring a pleasant sensory experience for consumers.

However, despite technological advances, aroma remains a deeply subjective experience. While instruments like **electronic noses (e-noses)** can mimic human olfactory responses to some degree, they cannot fully replicate the complexity of human scent perception. This limitation highlights the importance of **trained sensory panels**, composed of experts who can accurately describe and evaluate food aromas.

17.4.3. Flavor:

Flavor is one of the most multifaceted sensory experiences we have with food, often described as a combination of taste and aroma. While the terms "taste" and "aroma" are used to describe distinct sensory inputs, **flavor** is the result of how these senses work together to create the overall food experience. Understanding the science behind flavor involves exploring the intricate interaction between taste, smell, and additional sensory factors like mouth feel.

17.4.3.1. The Components of Flavor: Taste and Aroma

The perception of flavor is fundamentally a synthesis of multiple sensory signals. It can be broken down into three key components:

17.4.3.1.1 Taste: Taste is sensed primarily by the **taste buds** on the tongue and is limited to five basic categories: sweet, sour, salty, bitter, and umami. While taste alone provides important information about the chemical composition of food, it is often not sufficient to convey the full depth of flavor. Taste is essentially a chemical reaction where certain compounds, such as sugars, acids, and salts, stimulate specific receptors on the tongue.

17.4.3.1.2 Aroma (Smell): Aroma, or smell, is sensed by the **olfactory system**. When we eat, volatile compounds from the food are released into the air and detected by receptors in the nose. These compounds can be aromatic esters, terpenes or aldehydes each contributing to distinct characteristics such as fruity, floral, or spicy notes. Aroma is often what distinguishes one food from another and can strongly influence how we perceive the flavor. For example, a ripe mango may taste sweet, but its aroma of **linalool** (a citrus terpene) gives it its distinctive fragrance.

17.4.3.1.3 Mouth feel: Mouth feel refers to the physical sensations that we experience when food interacts with the mouth, such as astringency, temperature, or texture. This component of flavor is especially important in certain foods like spices, wine, and coffee, where sensations like the **bite** of a pepper or the **tannin** in wine can significantly alter the overall flavor experience. Astringency, for instance, is a drying sensation often caused by tannins in foods like unripe fruit or red wine.

17.4.3.2. How Taste and Aroma Combine to Form Flavor:

The relationship between taste and aroma is pivotal in the formation of flavor. **Taste**, limited to basic categories like sweet or salty, offers only a partial representation of a food's overall sensory profile. On the other hand, **aroma** provides a rich array of sensory details that complement taste. Together, they create a cohesive flavor profile that we experience as a unified whole.

Interestingly, the role of smell in flavor is so crucial that it's difficult to perceive the full flavor of food with a blocked nose. This is evident when individuals experience a cold or nasal congestion: foods may taste bland or dull, as the aroma cannot be properly detected, even though taste receptors on the tongue remain functional.

17.4.3.3. The Role of Aroma in Flavor Perception:

Aroma plays a dominant role in flavor perception, as it accounts for much of the complexity and intensity of flavor. Volatile organic compounds (VOCs) released from food during consumption stimulate the olfactory receptors in the nasal cavity. These compounds, including **esters**, **terpenes**, and **aldehydes**, are often the key contributors to the distinctive smells of foods. The interaction between aroma and taste receptors allows us to distinguish between foods, even if they share similar basic tastes.

For example, the complex aromas of coffee-ranging from **roasty** and **bitter** to **floral** and **earthy**-contribute much more to its flavor than the bitter taste alone. Similarly, the distinct smell of garlic, which comes from **diallyl disulfide**, is a major part of its characteristic flavor, enhancing the sensation of spiciness and savory notes.

17.4.3.4 Measuring Flavor Components: Practical Applications:

Understanding flavor requires the ability to measure both taste and aroma. Scientists use various techniques to analyze these components, which helps to improve food product development and quality control.

- **Chemical Analysis of Taste:** The basic tastes (sweet, sour, salty, bitter, and umami) can be measured chemically using techniques like **high-performance liquid chromatography (HPLC)** or **mass spectrometry**. These methods help identify and quantify specific compounds responsible for taste, such as sugars for sweetness or acids for sourness.

- **Aroma Analysis:** The analysis of aroma is often conducted using **gas chromatography** (GC), a technique that separates and identifies volatile compounds present in food. GC can measure compounds like **limonene** in citrus fruits or **eugenol** in cloves, helping scientists understand how these aromas contribute to the overall flavor profile. The resulting data can be used to optimize food formulations and ensure consistency in product flavor.
- **Sensory Evaluation:** While instrumental methods provide valuable insights, **human sensory evaluation** remains a critical tool in flavor analysis. Trained panels of testers use descriptive terms like **floral, spicy, fragrant,** or **acrid** to assess the overall flavor of food, combining information about taste, aroma, and mouth feel. This subjective evaluation can be correlated with consumer preferences, allowing food manufacturers to tailor products to meet specific tastes and preferences.

17.4.4. Appearance:

Appearance plays a crucial role in how food is perceived and consumed. From the moment food is presented, its visual attributes can influence our expectations of flavor, freshness, and quality. Among these attributes, **color** stands out as one of the most significant factors in determining how food is evaluated and enjoyed. For science students, exploring the relationship between color and food perception provides valuable insights into both the sensory science and practical applications in food production and quality control.

17.4.4.1 The Multifaceted Nature of Food Appearance:

Food appearance encompasses a wide range of sensory attributes, all of which can impact the overall eating experience. These include:

- **Size and Shape**: How the food is formed and its dimensions contribute to its visual appeal and practicality for consumption.
- **Ergonomics**: This refers to the ease with which the food can be handled or eaten.
- **Gloss and Shine**: The reflective qualities of the food's surface, often indicating ripeness or freshness.
- **Physical State**: Whether the food is solid, liquid, or semi-solid can affect its visual appeal and consumer preference.
- **Temperature**: Temperature influences the way food is visually perceived, such as the sheen of hot dishes or the chilled look of frozen foods.
- **Surface Texture**: This refers to the tactile characteristics visible on the food's surface, such as smooth, crispy, lumpy, or fibrous.

In all these factors, **color** is a dominant aspect, and its perception greatly influences how we judge the quality and appeal of food.

17.4.4.2 Understanding Color in Food:

The **color of food** is a direct result of the light that is either reflected by or transmitted through the food. It is the **energy distribution** across the visible spectrum that creates the colors we perceive. Human vision is sensitive to a narrow range of the electromagnetic spectrum, from **380 nm to 770 nm**, which is categorized as the visible range. This tiny portion of the spectrum contains all the colors we can see, from **violet** to **red**.

Color in food is critical not only for visual appeal but also for determining its ripeness, freshness, and even flavor expectations. For instance, the red of a ripe strawberry signals its sweet and juicy nature, while the yellow-orange of a bell pepper indicates its ripeness and flavor profile.

17.4.4.3 The Role of Color in Food Quality and Perception:

Color plays an essential role in food selection, preparation, and assessment. Key points to consider include:

- **Judging Ripeness and Freshness:** The color of fruits and vegetables is often the primary indicator of ripeness. A bright red apple or a yellow banana signifies that the fruit has reached its peak ripeness, while an unripe version will exhibit a different color, like green. Similarly, color helps assess the freshness of meat, seafood, and dairy products.
- **Quality Control in Food Production:** In industries such as food processing, color standards are often set to ensure consistency and meet regulatory guidelines. For example, **tomato products, mustard oil,** and **jams** are all subject to specific color standards. This ensures that consumers consistently receive high-quality products, as color can significantly influence perceptions of taste, quality, and shelf life.
- **Strength of Beverages:** The color of beverages like **coffee** and **tea** is often used to judge their strength. A darker coffee might be perceived as richer or more robust, while a lighter tea suggests a milder flavor. These color cues help consumers set expectations before even tasting the beverage.

17.4.4.4 Measuring Food Color: Instrumental Methods

While human perception of color is subjective and influenced by various environmental factors (like lighting), there are several instruments that can provide objective, reproducible measurements of food color. These measurements are essential for ensuring quality control in food production.

1) **Lovibond Tintometer:** The Lovibond Tintometer is used in industries such as oil production to assess the color of liquids. It provides a standardized measurement to evaluate color intensity and consistency in products like edible oils and other food liquids.

2) **Hunter Colorimeter:** The Hunter Colorimeter is a widely used instrument in food industries to measure color based on a three-parameter scale:

   a) **L (Brightness/Lightness)**: Represents the lightness of the color. A value of 0 indicates black, and 100 indicates white.

   b) **a (Redness/Greenness)**: A positive value indicates red, while a negative value indicates green.

   c) **b (Yellowness/Blueness)**: A positive value indicates yellow, and a negative value indicates blue.

   This system allows food manufacturers to measure and control color accurately, ensuring consistent product appearance.

3) **CIE System (Commission Internationale de l'Eclairage):** The **CIE system** is an international standard for color measurement and is based on three attributes:

   a) **Hue**: The actual color (red, blue, green, etc.).

   b) **Chroma**: The intensity or saturation of the color.

   c) **Brightness**: The lightness or darkness of the color.

   This system is widely used in industries that require precise color matching, such as in food packaging, processing, and quality control.

17.4.5. Texture:

Texture is one of the fundamental sensory attributes of food that significantly influences how it is perceived and enjoyed. Unlike color or aroma, which is primarily assessed visually and olfactorily, texture is mostly evaluated through touch and mouth-feel, making it a more complex and multifaceted characteristic. In food science, understanding texture is crucial not only for sensory analysis but also for product development, quality control, and consumer preference. This article delves into the science behind texture, its sensory evaluation, and the various terms used to describe its different aspects.

17.4.5.1. Defining Food Texture:

Food texture is a term used to describe the consistency, structure, and sensory qualities of a food item, primarily based on its physical state (solid, semi-solid, or liquid). Texture is assessed through both touch (with the hand) and oral cavity responses (through the tongue, teeth, and mouth). These tactile sensations collectively referred to as **mouth-feel,** play an essential role in determining the appeal and overall acceptability of food.

17.4.5.2. Describing Food Texture:

There are a wide variety of terms used to describe the texture of food, each reflecting specific sensory qualities. Some of these terms include:

- **Brittle**: Crumbles or breaks easily under pressure (e.g., crackers, brittle candy).

- **Rubbery**: Elastic and resistant to deformation (e.g., gum, overcooked meat).
- **Gritty**: The presence of small, hard particles that can be felt during chewing (e.g., undercooked grains).
- **Tender**: Soft and easy to chew, often used to describe meat or vegetables.
- **Crisp**: A firm texture that breaks or shatters when bitten (e.g., chips, fresh fruit).
- **Fluffy**: Light and airy texture, usually describing baked goods (e.g., cakes, meringues).
- **Mushy or Soggy**: Soft, often overly moist, and disintegrates when chewed (e.g., overcooked vegetables, wet bread).
- **Smooth**: No lumps or bumps; uniform consistency (e.g., cream, pudding).

The textural characteristics of food can also be assessed using terms related to **viscosity** for liquids and semi-solids. Terms like **runny, thick, watery**, and **fluid** describe the consistency of products like sauces, soups, and beverages.

17.4.5.3. The Role of Temperature in Texture Perception:

Temperature has a significant impact on the texture of food. It influences how foods feel in the mouth, affecting their softness, firmness, and overall mouth-feel. For example:

- **Cold** foods like ice cream or chilled beverages feel firm and often cause a cooling sensation in the mouth.
- **Hot** foods such as soup or coffee may feel smoother or more liquid due to the reduction in viscosity at higher temperatures.

Thus, temperature can modify the overall sensory experience of food and influence the consumer's perception of its texture.

17.4.5.4. Categories of Textural Characteristics:

Food texture can be broken down into three primary categories: **mechanical characteristics**, **geometrical characteristics**, and **moisture/fat perception**.

I. **Mechanical Characteristics**: These describe how food reacts to force and stress. Important primary mechanical properties include:

   a) **Cohesiveness**: The ability of a food to hold together when bitten or compressed (e.g., a chewy cookie vs. a soft one).

   b) **Hardness**: The force required to deform a food sample. For instance, a hard crust requires more force to bite than a soft loaf of bread.

   c) **Viscosity**: The force required to draw a liquid, like honey, from a spoon. This property is essential for liquids and semi-solids.

II. **Geometrical Characteristics**: These describe the size, shape, and orientation of particles in a food. For example:

   a) **Fracturability**: The ease with which a food breaks or shatters (e.g., the crunch of a cookie or the crumbliness of a pie crust).

   b) **Uniformity**: The consistency of particle size and distribution within a food item.

III. **Moisture and Fat Perception**: These refer to the sensory experience of moisture and fat content in food. Characteristics like **smoothness, moisture release**, and **greasiness** all depend on the balance of water and fat in the food, influencing mouth-feel.

17.4.5.5. Secondary Textural Properties:

In addition to the primary mechanical properties, there are several secondary properties that contribute to the overall texture of food:

- **Graininess**: The presence of fine particles that can be detected during chewing (e.g., grits or rough-textured bread).
- **Chewiness**: The effort required to break down a food during chewing (e.g., chewy meat or a dense loaf of bread).
- **Gumminess**: The energy needed to disintegrate semi-solid food into a swallowable state (e.g., gum or marshmallows).
- **Roughness**: The abrasiveness or texture perceived on the surface of the food (e.g., coarse bread crust).
- **Smoothness**: The absence of rough or gritty particles, giving the food a uniform texture (e.g., pudding or yogurt).
- **Slipperiness**: The ease with which food slides over the tongue, typically seen in moist or oily foods (e.g., oily fish or greasy pizza).

17.5 SUMMARY:

The importance of each quality attribute in food varies significantly depending on the type of product. For instance, **appearance**, primarily influenced by color and ergonomics, plays a crucial role in the consumer's initial perception. **Texture**, on the other hand, is determined by the physical state of the food, whether solid, semi-solid, or liquid, and is critical for evaluating mouth-feel and overall sensory experience. Additionally, **maturity** of the food (for fresh produce) and the **processing steps** involved in product development are fundamental factors influencing the final quality.

To accurately evaluate and ensure food quality, there are several **instrumental methods** available for assessing sensory parameters, helping to eliminate human bias in

measurements. However, in commercial applications, food quality is typically monitored using a combination of **trained panels** and **instrument-based judgments** by experts, ensuring that both objective and subjective evaluations are aligned. This integrated approach allows for the effective monitoring of product quality and consistency in the food industry.

17.6 TECHNICAL TERMS:

Sensory Attributes, Quality, Sensory Experience, Appearance, Sensory Receptors.

17.7 SELF ASSESSMENT QUESTIONS:

1) Explain the definition and importance of sensory evaluation?
2) What are the sensory receptors and their role in sensory evaluation?

17.8 REFERENCE BOOKS:

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LESSON-18

REQUIREMENTS TO CONDUCT SENSORY EVALUATION-SENSORY PANEL

OBJECTIVES:

After going through this lesson students will understand:

- State the role of sensory panelists, training and calibration in sensory evaluation;
- Standardized sensory evaluation protocol and testing environment;
- Ethical considerations, data collection and analysis in sensory evaluation.

STRUCTURE:

18.1 INTRODUCTION:

The food industry strives to develop products that not only provide nutritional benefits but also appeal to consumers' five senses-sight, smell, taste, touch, and sound. While nutritionists and dietitians focus on creating healthier recipes, the success of these products largely depends on sensory acceptance. The body’s senses act as gatekeepers, deciding whether a food product is accepted or rejected. Therefore, understanding consumer responses through sensory evaluation is a cornerstone of food product development.

Unlike laboratory apparatus, human perception is irreplaceable in evaluating food products. Although sensory studies can be expensive and are subject to human bias, they are becoming increasingly prevalent due to their unmatched ability to measure how food interacts with the senses.

18.2 SENSORY EVALUATION:

Sensory evaluation is a **scientific method** that evokes, measures, analyzes, and interprets human responses to products as perceived through the five senses.

This widely accepted definition is supported by professional organizations such as the **Institute of Food Technologists (IFT)** and the **American Society for Testing and Materials (ASTM).** Like any scientific measurement, sensory evaluation emphasizes **precision, accuracy, and sensitivity**, while also focusing on avoiding **false-positive results**.

18.3 REQUIREMENTS TO CONDUCT SENSORY EVALUATION:

During sensory evaluation, panelists are typically seated at tables, cubicles, or booths, and the food is presented in a uniform fashion. To obtain valid, reproducible results during a sensory evaluation, the environment in which the sensory panel evaluates foods or beverages should be carefully controlled, as should variables pertaining to the panelists.

18.3.1 SELECTION AND COMPOSITION OF THE SENSORY PANEL

Effective sensory evaluation relies heavily on the type of panel selected to carry out the testing. Panelists serve as the primary “instruments” for measuring the sensory attributes of food and beverages, so their selection, training, and management play a pivotal role in obtaining valid and meaningful results.

18.3.1.1 TYPES OF SENSORY PANELISTS

Sensory panelists are individuals selected to participate in sensory evaluation studies to assess the attributes of products such as taste, aroma, texture, appearance, and sound. The type of panelists required depends on the purpose of the study and the level of detail needed in the evaluation. Panelists can broadly be categorized based on their training, experience, and purpose in the evaluation process.

Here's a Table 18.1 on the Types of Sensory Panelists:

Table 18.1: Types of sensory panelists based on their roles, training, and evaluation focus, offering insights into their unique contributions to sensory evaluation.

Type of Sensory Panelist	Description	Key Characteristics
Trained Sensory Analyst	Panelists who have undergone formal training to evaluate sensory attributes systematically.	Skilled in detecting subtle differences, use specific terminology, follow standardized methods.
Consumer Panelist	General consumers who provide feedback based on personal preferences and experiences.	Represent the target market, provide subjective opinions, focus on overall liking or preference.
Specialized Expert Panelist	Individuals with extensive experience or specialized knowledge in a specific product category.	Expert in a particular domain, often involved in product development and quality control.
Descriptive Panelist	Trained to describe the sensory characteristics of products in detail, focusing on qualitative analysis.	Provide detailed sensory profiles, use descriptive language, often involved in research.
Discriminative Panelist	Panelists trained to identify differences between products, often used in quality control.	Focus on detecting and describing differences, may participate in triangle tests or paired comparisons.
Affective Panelist	Panelists who assess the hedonic or emotional response to products, focusing on preference and acceptance.	Provide feedback on liking, preference, and emotional responses, typically non-trained.

A) Trained Panelists:

Trained panelists are individuals who have undergone extensive training to evaluate sensory attributes with precision and consistency. They are typically used for analytical sensory evaluations where detailed and objective data is needed.

- **Characteristics:**
  - Ability to identify and describe subtle differences in sensory attributes.
  - Trained to use specific sensory techniques and scales, such as flavor profiling or texture analysis.
  - Familiarity with terminology and sensory concepts.
- **Applications:**
  - Product development and reformulation.
  - Quality control to ensure consistency in product attributes.
  - Comparative analysis between products or formulations.

- **Examples:**
    - Experts evaluating wine, chocolate, or coffee for quality and flavor notes.
    - Food scientists assessing the textural properties of processed foods.

B) Semi-Trained Panelists:

Semi-trained panelists receive some level of instruction but lack the rigorous training of professional sensory analysts. They bridge the gap between trained and untrained panelists, providing moderately detailed feedback.

- **Characteristics:**
    - Familiarity with basic sensory evaluation techniques and terminology.
    - Ability to follow instructions and use simple sensory scales.
- **Applications:**
    - Initial screening of new product formulations.
    - Quality assurance tasks requiring moderately detailed evaluations.
- **Examples:**
    - Employees in a food manufacturing facility conducting routine sensory checks.

C) **Untrained Panelists (Consumer Panelists):**

Untrained panelists are everyday consumers with no prior training in sensory evaluation. Their primary role is to provide subjective feedback based on personal preferences and overall liking of a product.

- **Characteristics:**
    - Represent a target consumer demographic.
    - Evaluate products based on personal perception and preferences.
    - Limited ability to identify specific sensory attributes or use technical language.

- **Applications:**
    - Consumer preference studies and hedonic testing.
    - Identifying market acceptance of new products.
    - Testing products against competitors in a target market.
- **Examples:**
    - A group of individuals from a target age group rating the taste of a new soft drink.
    - Customers participating in a taste test for a new snack product.

D) Specialized Panelists:

Specialized panelists are individuals selected for their unique expertise, sensory abilities, or specific demographic attributes. They are chosen for evaluations requiring specialized knowledge or experiences.

- **Subcategories:**
    - **Expert Panelists:**
        - Professionals with deep expertise in a specific domain, such as chefs, sommeliers, or coffee tasters.
        - Used for high-end product evaluations requiring refined judgment.
    - **Target Group Panelists:**
        - Consumers chosen based on specific characteristics, such as age, cultural background, dietary preferences, or health conditions.
        - Used to evaluate products for niche markets (e.g., gluten-free foods, low-sugar beverages).
    - **Sensitive Panelists:**
        - Individuals with heightened sensory perception, such as supertasters, who are more sensitive to certain flavors like bitterness or sweetness.
        - Used for detailed evaluations of subtle flavor differences.

E) **Internal vs. External Panelists:**

- **Internal Panelists:**
    - Employees of a company, often from R&D or quality control departments.
    - Familiar with the product and company goals, making them suitable for preliminary evaluations.

- **External Panelists:**
    - Independent individuals from outside the organization, often consumers or contracted experts.
    - Provide unbiased and fresh perspectives on the product.

F) **Panelist Selection Criteria:**

a) Sensory Sensitivity:

- Panelists must demonstrate the ability to detect and differentiate between basic sensory attributes such as taste, aroma, texture, and appearance.
- Screening tests (e.g., basic taste recognition, aroma identification, and texture differentiation) are used to assess sensory acuity.

b) Health Conditions:

- Panelists must be free from health conditions that could impair their senses (e.g., colds, allergies, or chronic conditions like anosmia).
- Good dental health is essential to avoid interference with texture or flavor perception.

c) Lifestyle Factors:

- Avoid individuals who smoke, consume excessive alcohol, or are heavily dependent on caffeine, as these habits may dull sensory perception.
- Ensure panelists refrain from consuming strong flavors or odors (e.g., spicy foods, garlic, or perfume) before the evaluation.

d) Demographics:

- For consumer panels, ensure that panelists represent the target population in terms of age, gender, cultural background, and lifestyle.
- For trained panels, demographic diversity may be less important than sensory acuity and ability.

18.3.1.2 TRAINING AND CALIBRATION IN SENSORY EVALUATION:

Training and calibration are essential components of sensory evaluation, particularly for trained panels. They ensure that panelists develop the skills, consistency, and reliability required for evaluating sensory attributes accurately. Here is a detailed breakdown of the training and calibration processes:

A) Importance of Training and Calibration:

- **Training** develops panelists' ability to identify, quantify, and describe sensory attributes accurately.

- **Calibration** ensures uniformity in panelists' perceptions and ratings, reducing variability and increasing the reliability of the data.

Both processes are crucial for maintaining the credibility and scientific rigor of sensory evaluation results.

B) Components of Training:

a) Understanding Sensory Attributes: Panelists must be familiar with the sensory attributes relevant to the product being tested. These attributes typically include:

- **Appearance**: Color, size, shape, and visual texture.
- **Aroma**: Identification of specific smells or odors.
- **Taste**: Basic tastes (sweet, sour, salty, bitter, umami) and their intensities.
- **Texture**: Mouth feel attributes such as crispness, creaminess, or firmness.
- **Aftertaste**: Lingering sensations or flavors after consumption.

b) Terminology Development: Panelists are introduced to standardized sensory vocabularies for describing products. For descriptive analysis, a lexicon of terms specific to the product category is developed (e.g., "earthy" for coffee, "buttery" for wine).

c) Sensory Attribute Recognition: Reference Standards: Panelists are exposed to physical samples representing various sensory attributes. For example:

- Sweetness: Solutions with different sugar concentrations.
- Bitterness: Solutions with known caffeine levels.
- Texture: Materials with varying hardness (e.g., gels or calibrated food products).

d) Scale Training: Panelists learn to use evaluation scales effectively: Intensity scales (e.g., 0–10, where 0 represents absence and 10 represents extreme intensity). Hedonic scales for consumer acceptability (e.g., 9-point hedonic scale).

e) Practice Sessions:

- **Mock Tests**: Conduct practice evaluations to help panelists apply learned skills in a realistic setting.
- **Feedback**: Provide constructive feedback on their performance to improve accuracy and consistency.

C) Types of Training Methods:

a) Basic Sensory Training: Focuses on improving sensory acuity (e.g., distinguishing between basic tastes, detecting small differences in aromas). Often includes threshold tests to measure sensitivity to specific attributes.

b) Product-Specific Training: Tailored to the product category being evaluated (e.g., chocolate, dairy, beverages).Involves familiarization with specific attributes and typical variations within the product category.

c) Descriptive Analysis Training: Used for panels conducting detailed product profiling. Involves training panelists to evaluate multiple attributes, often with a specific lexicon.

d) Analytical Training: Focuses on discrimination tests such as triangle tests or paired comparisons.

D) Components of Calibration:

Calibration aligns the panel's evaluations to ensure consistency over time and across individuals.

a) Use of Reference Samples: Present panelists with standardized samples representing specific attributes or intensity levels.

- Examples:
  - A series of salt solutions for salty taste.
  - Textured gels for firmness.
  - Regular exposure to these references ensures panelists remain consistent in their assessments.

b) Repeatability Testing: Panelists evaluate the same sample multiple times under similar conditions to assess repeatability. Results are analyzed to identify variability in individual performance.

c) Consensus Building: Discuss discrepancies among panelists to reach a consensus on the interpretation of attributes. Group discussions help align perceptions and resolve misunderstandings.

d) Statistical Monitorin: Use statistical tools (e.g., Analysis of Variance, standard deviations) to monitor panelist consistency. Identify outliers and provide targeted retraining if needed.

e) Regular Calibration Exercise: Conduct periodic calibration sessions to maintain alignment over time, especially in long-term studies.

E) Tools and Techniques for Training and Calibration:

a) Sensory Standards: Use validated reference materials (e.g., International Organization for Standardization standards for sensory evaluation).

b) Interactive Tools: Digital tools and software can simulate sensory environments and provide training exercises.

c) Performance Tracking: Keep records of panelist performance over time, including individual variability and improvement.

18.3.1.3 TESTING ENVIRONMENT:

The testing environment plays a crucial role in sensory evaluation, as it ensures that external factors do not influence the panelists' perceptions or responses. A well-designed testing environment minimizes distractions, maintains consistency, and creates controlled conditions for reliable and valid results. Below are the detailed requirements for setting up an optimal testing environment for sensory evaluation:

a) Physical Setup:

- **Sensory Booths**: Individual, isolated booths minimize distractions and communication between panelists.
- **Lighting**: Neutral or adjustable lighting to avoid bias, such as masking appearance differences in food samples.
- **Ventilation**: Odor-free environment to avoid interference.
- **Temperature and Humidity**: Controlled conditions to ensure comfort and consistent product presentation.

b) Sample Presentation:

- **Standardized Preparation**: Prepare and serve samples under uniform conditions (e.g., temperature, size, and cooking method).
- **Randomization**: Present samples in a randomized order to avoid sequence bias.
- **Neutral Codes**: Use anonymous coding (e.g., three-digit numbers) for sample identification.

c) Timing:

- Schedule tests at optimal times, avoiding early morning, late evening, or directly after meals.
- Provide adequate time between samples to avoid sensory fatigue or carryover effects.

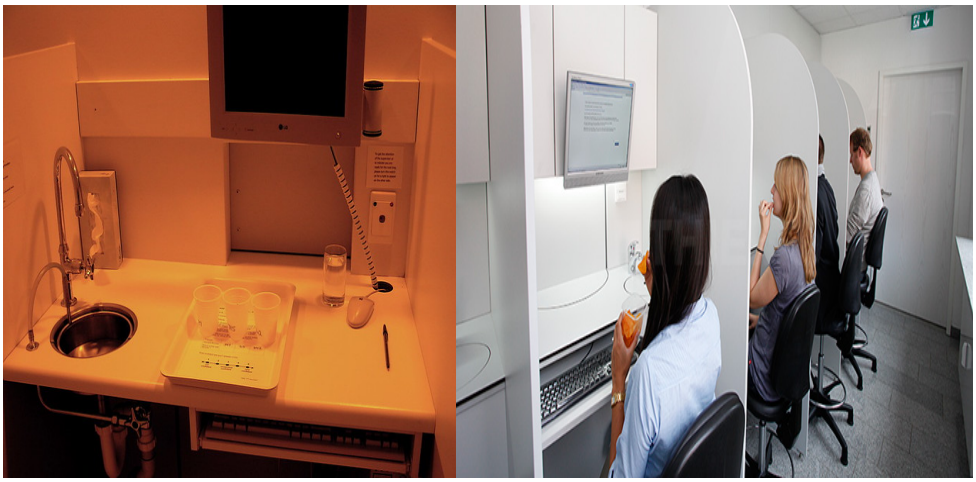

Fig. 18.1: Sensory Analysis Booths

18.3.1.4. STANDARDIZED SENSORY EVALUATION PROTOCOLS:

a) Clear Objectives: Define the purpose of the evaluation, such as preference testing, descriptive analysis, or discrimination testing.

b) Test Design: Choose appropriate sensory evaluation methods, such as:

- **Hedonic Testing**: Measures consumer acceptance or liking.
- **Descriptive Analysis**: Evaluates the intensity of specific sensory attributes.
- **Discrimination Tests**: Determines if differences exist between samples (e.g., triangle tests, paired comparisons).

c) Instructions to Panelists

- Provide clear, written, and verbal instructions on how to evaluate and record responses.
- Ensure understanding of scales, attributes, and procedures.

d) Evaluation Tools

- Use standardized scoring sheets or digital tools for data collection.
- Provide scales for rating intensity, preference, or acceptability (e.g., 9-point hedonic scale or 0–10 intensity scale).

18.3.1.5. DATA COLLECTION AND ANALYSIS:

a) Accurate Data Recording:

- Collect responses systematically to ensure data integrity.
- Use digital or manual systems for recording panelist scores and comments.

b) Statistical Analysis:

- Analyze data using appropriate statistical methods, such as Analysis of Variance (ANOVA), to identify significant differences or trends.

18.3.1.6. ETHICAL CONSIDERATIONS:

- **Informed Consent**: Ensure panelists understand the purpose of the evaluation and provide consent.
- **Confidentiality**: Protect panelist identities and responses.
- **Voluntary Participation**: Allow panelists to withdraw at any time without consequences.
- **Fair Compensation**: Provide reasonable incentives for participation.

18.3.1.7. DOCUMENTATION AND QUALITY CONTROL:

a) Record Keeping: Maintain records of panelist profiles, training, test conditions, and results for reproducibility and quality assurance.

b) Quality Control: Monitor and address variability in panelist responses or test conditions. Conduct periodic reviews of protocols and panelist performance.

18.3.1.8. LONG-TERM PANEL MANAGEMENT:

a) Retention of Panelists*:* Use incentives to maintain panelist motivation and commitment. Offer ongoing training and feedback to improve skills and engagement.

b) Panel Maintenance: Regularly assess and refresh the panel to address attrition or performance issues. Gradually introduce new panelists to maintain panel continuity**.**

18.4 SUMMARY:

A well-structured sensory panel is at the heart of effective sensory evaluation. Meeting the essential requirements for panelists, testing environments, training, and management ensures the reliability, accuracy, and validity of the data collected. By addressing these requirements, organizations can achieve a robust sensory evaluation process that provides actionable insights into product quality, consumer preferences, and innovation opportunities.

The foundation of any sensory panel lies in the **selection of appropriate panelists**-individuals with the necessary sensory acuity, motivation, and ability to provide unbiased and consistent feedback. Complementing this is the **creation of a controlled testing environment**, which eliminates external distractions and biases, allowing panelists to focus entirely on the sensory attributes of the product. Comprehensive **training and calibration** further enhance panelists' ability to provide consistent and reliable assessments by standardizing perceptions and evaluation criteria.

Equally important is **panel management**, which includes monitoring performance, providing constructive feedback, and maintaining motivation and engagement. These efforts not only ensure long-term consistency but also foster a sense of professionalism and commitment among panelists.

Incorporating these requirements into the sensory evaluation process benefits both industry and research contexts. For industries, it ensures products meet consumer expectations, enabling better market positioning and reduced risks. In research, it supports the generation of credible, reproducible data for scientific studies.

Ultimately, a well-executed sensory evaluation panel serves as a critical tool for decision-making in product development, quality control, and consumer insights, driving innovation and success in highly competitive markets.

18.5 TECHNICAL TERMS:

Sensory Panel, Sensory Evaluation Protocol, Ethical Considerations, Data Collection.

18.6 SELF ASSESSMENT QUESTIONS:

1) What is a sensory panel?
2) List the types of sensory panel?
3) Explain training and calibration in sensory evaluation?

18.7 REFERENCE BOOKS:

1) Sharma A., Textbook of Food Science and Technology, 3rd Edition, 2019.
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4) M.S. Swaminathan, Food Science, 1987.

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LESSON-19

PREPARING AND PRESENTING SAMPLES FOR TESTING, PANEL BOOTH

OBJECTIVES:

After going through this lesson students will understand:

- General requirements of sample preparation and presentation
- Scale of samples and its principles;
- Importance of Panel Booths in Sensory Evaluation

STRUCTURE:

19.1 INTRODUCTION:

Samples should be prepared in a way that brings out the differences in a particular quality attribute under evaluation. All variables such as temperature, time of boiling, quantity and composition of water and blending etc., should be controlled to ensure identical method preparation methods for all samples. Care should be taken that no loss of flavour occurs and no foreign tastes or odours are imparted by the procedure during preparation, storage, serving, etc.

19.2 GENERAL REQUIREMENTS OF SAMPLE PREPARATION:

Sample preparation is a crucial step in sensory evaluation. The goal is to ensure that the differences observed by panellists arise from the product's inherent qualities rather than inconsistencies in preparation, handling, or presentation. Adhering to precise preparation principles ensures accurate and reproducible results.

19.2.1 EMPHASIZING THE TARGET ATTRIBUTE:

- Prepare samples to highlight the specific quality attribute under evaluation, such as sweetness, texture, or aroma.
- Modify preparation techniques as needed to enhance the detectability of the targeted characteristic without introducing biases.

19.2.2. CONSISTENCY ACROSS SAMPLES:

- All samples should be prepared using an identical method to maintain uniformity. Variations in preparation can introduce biases and obscure meaningful differences.
- Examples of controlled factors:
    - Temperature of cooking or serving.
    - Mixing or blending processes.
    - Quantity and quality of ingredients used.

19.2.3. CONTROLLING VARIABLES IN PREPARATION:

- External variables must be minimized to ensure comparability. Key factors include:
    - **Time:** Standardize cooking, cooling, or resting times.
    - **Temperature:** Ensure consistent temperatures during cooking, storage, and serving.
    - **Equipment:** Use the same tools and utensils for all samples to avoid introducing variability.
    - **Water Composition:** Use identical water sources and volumes to avoid subtle influences on taste or texture.

19.2.4. PREVENTING FLAVOR LOSS:

- Ensure that the preparation process preserves the product's natural flavours and sensory attributes:
    - Avoid excessive exposure to air, light, or heat, which may degrade volatile compounds.
    - Store samples in airtight, odor-free containers until serving.

19.2.5. AVOIDING FOREIGN TASTES AND ODORS:

- Use clean and neutral equipment, utensils, and storage materials to prevent contamination.
- Ensure the preparation and serving environment is free from strong odors or flavours that may influence perception.

19.2.6. PRESENTING SAMPLES UNIFORMLY

- Serve samples in identical portions, containers, and presentation styles to minimize visual or textural biases.
- Randomize sample order when presenting to prevent order effects.

19.2.7. PRACTICAL IMPLEMENTATION EXAMPLE:

Imagine testing the saltiness of potato chips:

1) **Target Attribute:** Focus on saltiness by ensuring chips are not flavoured with other seasonings.
2) **Consistency:** Ensure chips are sourced from identical batches and stored under identical conditions.
3) **Controlled Variables:** Serve chips at room temperature with no added condiments.
4) **Flavor Preservation:** Use airtight containers to prevent loss of crispness or absorption of ambient odors.
5) **Uniform Presentation:** Serve an equal weight of chips in identical bowls.

19.3 SCALE OF SAMPLING:

Sampling is a foundational step in sensory evaluation, determining how and which products are selected for testing. The sampling scheme directly influences the reliability and applicability of the results. A well-designed sampling plan ensures that the products tested are representative of the broader batch or production run, enabling accurate assessments of sensory attributes.

19.3.1. PRINCIPLES OF SAMPLING

19.3.1.1. Follow Commodity-Specific Guidelines:

- Sensory evaluation sampling schemes should adhere to the commodity-specific specifications outlined for the product under evaluation.
- These guidelines are designed to address the unique characteristics of individual commodities (e.g., beverages, baked goods, dairy) and should serve as a reference for similar products.

19.3.1.2. Representativeness:

- Samples must represent the entire batch or production run to ensure results reflect the product's overall quality.
- Factors to consider include:

- **Batch Variability:** Sampling from different production lots or time intervals.
- **Packaging Influence:** Testing products from different packaging or storage conditions.

19.3.1.3 Details of Sampling in Results:

- When presenting sensory evaluation results, detailed information about the sampling process should be included. This allows others to:
  - Evaluate the validity of the conclusions.
  - Replicate the study if needed.
- Key details to include:
  - Sampling size and method (random, stratified, etc.).
  - Source and location of samples.
  - Time and conditions of sampling.

19.3.2 EXAMPLE OF SAMPLING SCHEME:

For a sensory evaluation of packaged fruit juices:

- **Guideline-Based Sampling:** Follow standards outlined for fruit beverages in relevant commodity specifications.
- **Selection:** Randomly select samples from multiple production lots to account for variability.
- **Storage and Transportation:** Ensure samples are stored under identical conditions and transported to the sensory lab in a consistent manner.
- **Documentation:** Record and report details such as the production date, lot number, and storage conditions of each sample.

19.4 PRESENTATION OF SAMPLES:

The presentation of samples plays a pivotal role in sensory evaluation, as inconsistencies can introduce bias and compromise the reliability of results. Uniformity in sample presentation ensures that differences observed during testing are solely attributable to the inherent qualities of the products being evaluated.

19.4.1 PRINCIPLES OF SAMPLE PRESENTATION

19.4.1.1 Uniformity within a Test: Ensure all samples are presented in a consistent manner during a single test session. This includes:

- **Portion Size:** Present equal amounts of each sample.
- **Containers:** Use identical serving containers to avoid influencing perceptions of appearance, texture, or temperature.

- **Labelling:** Use random codes or neutral labels instead of brand names or descriptive terms to prevent cognitive bias.

19.4.1.2 Consistency Across Tests:

- For tests conducted across multiple sessions or with similar products, maintain a consistent presentation style:
    - The same serving dishes and utensils should be used for each session.
    - Samples should be served at the same temperature and under similar lighting conditions.

19.4.1.3 Order of Presentation:

- **Randomization:** Vary the sequence in which samples are presented to each panelist to eliminate order effects.
- **Balancing:** Ensure all samples appear an equal number of times in each position of the order to reduce positional bias.

19.4.1.4 Environmental Controls:

- Serve samples in a neutral environment, free from distractions such as strong odors, noise, or visual clutter.
- Use appropriate lighting to avoid visual distortions or masking of appearance-related attributes.

19.4.1.5 Preparation for Sensory Panellists:

- Provide clear instructions to panellists on how to evaluate samples.
- Offer palate cleansers (e.g., water, plain crackers) between samples to minimize carryover effects.

19.4.1.6 Practical Example:

For a sensory test evaluating yogurt flavours:

- **Within-Test Uniformity:** Serve equal portions in identical white cups, labelled with random three-digit codes.
- **Across-Test Consistency:** Ensure the same type of spoon and room temperature are used for all test sessions.
- **Randomization:** Randomly assign the order in which panellists taste vanilla, strawberry, and plain yogurt samples.

19.4.2 SIZE OF SAMPLES:

The size of the sample provided to panellists during sensory evaluation is an essential consideration, as it directly influences the ability to make accurate judgments. The goal is to ensure that the amount is sufficient for evaluation without overwhelming the panelist or introducing unnecessary variability.

19.4.2.1 Guidelines for Sample Size:

19.4.2.1.1 Sufficiency for Judgments: Panellists should receive enough of the sample to allow for thorough assessment. In difference tests, the minimum amount provided should enable panellists to perform approximately three evaluations (e.g., sips or bites).

- **Recommended Quantity:** A sample size of about 30 grams is typically sufficient for most sensory evaluations. Adjustments can be made based on the product type and the test's specific requirements.

19.4.2.1.3 Single-Try Instructions: If the test procedure does not require multiple evaluations, panellists may be instructed to try each sample only once. In such cases, smaller sample sizes can be used.

19.4.2.1.4 Avoid Full-Serving Quantities: Unless the evaluation involves testing a single sample, full normal serving sizes should not be provided, even if the material is readily available. This helps prevent sensory fatigue and ensures panellists remain focused on specific attributes.

- **Adjustment by Test Type:** For intense or strong-flavoured products (e.g., hot sauce, spices), smaller quantities may be necessary to avoid overwhelming the senses.
- For mild or low-intensity products, a slightly larger sample size might be required to ensure the panelist can detect subtle differences.

19.4.2.2 Practical Examples:

- **Beverages:** Provide approximately 30 ml of juice for each panelist in small, identical cups.
- **Solid Foods:** For crackers or cookies, offer a single piece weighing around 30 grams.
- **Intense Flavours:** For hot sauces, a smaller sample of about 5–10 grams may suffice, served with a neutral carrier like plain bread.

19.4.3 TEMPERATURE OF SAMPLES:

The temperature at which samples are presented plays a critical role in sensory evaluation. It can significantly influence the perception of sensory attributes such as flavour, texture, and aroma. Proper temperature control is essential to ensure accurate and meaningful results.

19.4.3.1 Guidelines for Sample Temperature

19.4.3.1.1 Room Temperature for Convenience:

- **General Testing:** Presenting samples at room temperature is preferred for ease of preparation and consistent control.

- This approach minimizes the impact of fluctuating environmental conditions and ensures uniformity across samples.

19.4.3.1.2 Difference Testing:

- Samples should be served at a temperature that **enhances the probability of discrimination** between products.
- For example, subtle flavor differences may be more discernible at slightly elevated or cooled temperatures, depending on the product type.

19.4.3.1.3 Preference Testing:

- For consumer preference tests, samples should be presented at temperatures that reflect **typical consumption practices** for that product.
- Example: Serve ice cream chilled or soup warm to replicate real-life eating conditions.

19.4.3.1.4 Uniform Utensils and Containers:

- All samples must be served in **identical utensils** that are appropriate in size, shape, and color.
- Utensils should be neutral and should not impart any taste or odor to the samples.

19.4.3.2 Practical Examples:

- **Hot Beverages (e.g., tea or coffee):**
  - Serve at a consistent warm temperature, approximately 60–65°C, to capture both aroma and taste accurately.
- **Chilled Desserts (e.g., yogurt or ice cream):**
  - Present at their optimal serving temperature (e.g., 0–4°C for yogurt, -12°C for ice cream).
- **Room Temperature Snacks (e.g., crackers or chocolate):**
  - Serve at ambient temperature to ensure consistency and avoid melting or texture changes.

19.4.4 TIME OF TESTING SAMPLES:

The timing of sample testing in sensory evaluation is crucial to maintaining the integrity and reliability of the results. Variations in timing can affect panellists' performance, introduce biases, and influence the perception of sensory attributes such as flavour, aroma, and texture.

19.4.4.1 Guidelines for Timing in Sensory Evaluation

19.4.4.1.1 Consistency across Tests: Ensure all panellists evaluate samples within the same time frame to minimize differences caused by external factors like environmental changes or sample degradation.

19.4.4.1.2 Appropriate Testing Windows: Conduct sensory evaluations at times when panellists are neither hungry nor overly full, as these conditions can affect taste perception.

- Mid-morning (around 10 a.m.) or mid-afternoon (around 2–3 p.m.) are often ideal, as panellists are likely to be alert and in a neutral state of hunger.

19.4.4.1.3 Sample Freshness: Serve samples promptly after preparation to preserve their sensory qualities. Foods prone to rapid quality changes (e.g., fried foods or beverages with carbonation) should be tested immediately after preparation to capture their intended attributes.

19.4.4.1.4 Breaks Between Tests: Allow sufficient time between testing sessions to avoid sensory fatigue, particularly in evaluations involving strong or complex flavors.

19.4.4.1.5 Controlled Duration:

- Specify a consistent duration for panellists to evaluate each sample to ensure uniform testing conditions.
- For example, panellists may be given 1–2 minutes per sample in a controlled test environment.

19.4.4.2 Practical Considerations

19.4.4.2.1 Morning vs. Afternoon Sessions:

- Avoid scheduling tests too early in the morning, as some panelists may still have residual effects from breakfast. Evening sessions may introduce variability due to fatigue or distractions.
- **Sequential Testing:** When multiple samples are evaluated in sequence, randomize the order to minimize biases caused by carryover effects or fatigue.

19.4.4.2.3 Test-Specific Timing: For temperature-sensitive foods (e.g., soup or ice cream), ensure that samples are tested at their optimal serving temperature by minimizing delays between preparation and presentation.

19.4.4.3 Why Timing Matters:

- **Panellist Performance:** The timing of the test affects panelists' focus, hunger state, and overall ability to evaluate samples accurately.
- **Sample Integrity:** Timely testing preserves the sensory properties of the samples, ensuring panellists experience the product as intended.
- **Reproducibility:** Consistent timing across sessions ensures the reliability of results and enables comparisons between tests.

19.4.5 ELIMINATION OF BIAS: Bias in sensory evaluation can significantly distort results, making it critical to eliminate or minimize its effects. Bias can arise from the panellists, the test design, or the testing environment, and addressing these sources is key to obtaining reliable and objective results.

19.4.5.1 Strategies for Eliminating Bias:

19.4.5.1.1 Randomized Sample Presentation: Present samples in a **randomized order** to prevent positional bias, where the sequence of tasting influences panellists' perceptions.

19.4.5.1.2 Use a **balanced presentation order** to ensure all samples are equally represented in each position.

19.4.5.1.3 Use of Blinding:

- Label samples with **neutral, random codes** (e.g., three-digit numbers) rather than descriptive names or product details.
- Ensure panellists do not know which sample corresponds to a specific product or treatment.

19.4.5.1.4 Controlled Testing Environment:

- Maintain a neutral testing environment by avoiding external cues such as brand logos, packaging, or discussions that could influence panellists.
- Use uniform lighting, temperature, and serving conditions for all samples.

19.4.5.1.5 Standardized Instructions:

- Provide clear, consistent instructions to all panellists to reduce variability in their approach to evaluating samples.
- Ensure panellists understand the test's objectives without revealing unnecessary details that might introduce bias.

19.4.5.1.5 Avoid Leading Questions:

- During preference or descriptive testing, use neutral phrasing in questionnaires to avoid influencing panellists' responses.
- Example: Instead of asking, "Do you find this sample too salty?" ask, "How would you describe the saltiness of this sample?"

19.4.5.1.7 Panellist Selection and Training:

- Select panellists with no prior knowledge of the samples or affiliations with the product being tested.
- For descriptive tests, train panellists to focus on objective sensory attributes rather than personal preferences.

19.4.5.1.8 Test Repetition and Cross-Validation:

- Repeat tests with different panellists or under varying conditions to ensure consistent results.
- Cross-validate findings by comparing results from multiple sensory methods or panels.

19.4.5.2 Practical Example:

For a sensory evaluation comparing two brands of orange juice:

- **Randomization:** Serve the samples in a randomized order labelled "435" and "298."
- **Blinding:** Ensure panellists do not know which sample corresponds to which brand.
- **Environment:** Conduct the test in a neutral room without visible product branding or packaging.
- **Instructions:** Instruct panellists to rate sweetness, acidity, and overall flavour using a predefined scale without discussing the samples.

19.4.6 NUMBER OF SAMPLES:

The number of samples presented during sensory evaluation is a critical factor that influences the accuracy, efficiency, and reliability of the test results. Too many samples can lead to sensory fatigue, while too few may limit the depth of analysis or the ability to detect differences.

19.4.6.1 Directions for Determining Sample Numbers

19.4.6.1.1 Objective of the Test:

- The number of samples should align with the purpose of the evaluation:
  - **Difference Tests:** Typically involve 2–3 samples to compare specific attributes or detect variations.
  - **Preference Tests:** May include 2–5 samples to assess consumer preferences.
  - **Descriptive Analysis:** Often limited to 3–4 samples per session to ensure detailed attribute profiling.

19.4.6.1.2 Avoid Sensory Fatigue:

- Limit the number of samples per session to prevent panellists from becoming overwhelmed or losing focus.
- Generally, 6–8 samples are considered the maximum for a single session, with breaks between evaluations if needed.

19.4.6.1.3 Product Characteristics:

- For products with intense flavours (e.g., spicy foods or strong beverages), fewer samples should be presented to avoid overwhelming the senses.
- For mild or neutral products (e.g., water or plain crackers), a slightly higher number of samples may be acceptable.

19.4.6.2 Practical Recommendations:

- **Triangle Tests (Difference Testing):** Present 3 samples, with 2 identical and 1 different, to identify variations.
- **Hedonic Testing (Preference):** Use 3–5 samples to assess preferences without causing sensory fatigue.
- **Descriptive Testing:** Limit to 4 samples to enable detailed attribute evaluation.
- **Consumer Testing:** When testing with large groups, present up to 6 samples with clear instructions to manage time and focus effectively.

19.4.7 SAMPLE CODING:

Sample coding is an essential technique in sensory evaluation, ensuring that the evaluation process remains objective and unbiased. By masking the identity of the samples, coding helps prevent panellists from being influenced by prior knowledge, packaging, or brand associations. It also maintains the integrity of the test and ensures that the results reflect the sensory attributes of the samples rather than external factors.

19.4.7.1 Importance of Sample Coding:

19.4.7.1.1 Eliminates Bias: Coding samples with neutral, random identifiers prevents panelists from associating samples with specific brands or products.

- This helps avoid bias based on preconceived notions or prior experiences.

19.4.7.1.2 Ensures Objectivity: By using random codes (e.g., numerical or alphanumeric), the analyst can ensure that panellists evaluate the samples purely based on sensory properties such as taste, texture, and aroma.

19.4.7.1.3 Maintains Confidentiality: In some cases, sample coding ensures that the identities of the products are not disclosed until after the test, which can be important in competitive testing or product development scenarios.

19.4.7.1.4 Supports Statistical Analysis: Random coding helps in eliminating any patterns that could arise from panelists' tendencies to compare samples sequentially. It ensures that data analysis is unbiased and more statistically valid.

19.4.7.2 Best Practices for Sample Coding:

19.4.7.2.1 Randomization:

- Use random codes for each sample (e.g., 1, 2, 3 or A, B, C) to ensure that no patterns are visible to the panellists.
- If there are multiple rounds or different product categories, maintain a consistent coding system.

19.4.7.2.2 Consistent Labelling:

- Ensure the codes are used consistently across all stages of the evaluation (preparation, serving, and data collection).
- Avoid using any identifying information (e.g., product name, manufacturer) in the codes.

19.4.7.2.3 Neutral Code Assignment: Assign codes in a neutral manner, ensuring that the numbers or letters used are not suggestive of any product attributes.

19.4.7.2.4 Clear Documentation:

- Keep a detailed record of the sample codes, so that the sensory analyst can correlate the samples with their corresponding characteristics after the test is complete.
- This is essential for data analysis, as well as for ensuring that the test process is transparent and repeatable.

19.4.7.2.5 Blind Testing: Ideally, the panellists should not have any knowledge of the product identity during the evaluation, which is where coding plays a key role. If possible, ensure that samples are served in a blind manner, with no cues or identifiers present in the testing environment.

19.4.7.3 Practical Example of Sample Coding:

For a sensory evaluation comparing two brands of yogurt:

- **Step 1:** Label each yogurt sample with random numerical codes, such as "X23" and "B56."
- **Step 2:** The samples are served to panellists without any indication of which sample corresponds to which brand.
- **Step 3:** Panellists evaluate the yogurt based on attributes like creaminess, sweetness, and flavour, without knowing the product identity.
- **Step 4:** After testing, the codes are matched back to their corresponding brands for data analysis and comparison.

19.4.8 Order of Sample Presentation:

The order in which samples are presented during sensory evaluation can significantly influence panellists' perceptions and the overall accuracy of the results. By carefully controlling the sequence of sample presentation, sensory analysts can minimize biases and ensure that the results reflect the true sensory qualities of the samples.

19.4.8.1 Why the Order of Presentation Matters:

19.4.8.1.1 Preventing Position Bias: Panellists may develop preferences or biases based on the position of the sample, particularly if they are exposed to samples in a fixed order. For example, they may rate the first sample more favourably simply because it is tasted first.

19.4.8.1.2 Eliminating Carryover Effects: Tasting one sample can affect the perception of subsequent samples due to lingering flavours or aromas. The order of presentation can either mitigate or exacerbate this effect.

19.4.8.1.3 Ensuring Fair Comparison: Presenting samples in a randomized order or using counterbalancing methods ensures that each sample is evaluated independently of others, leading to more objective and reliable results.

19.4.8.2 Practical Example of Sample Presentation Order

Consider a sensory evaluation of three different types of fruit juices:

- **Step 1:** Randomly assign the order of samples for each panelist. Sample order could be A, B, C for one panelist and C, A, B for another.
- **Step 2:** Ensure that panellists taste each juice in a neutral environment, with no distractions.
- **Step 3:** Use a palate cleanser, such as water or crackers, between tasting each juice to reset their sensory perception and avoid flavour carryover.
- **Step 4:** Collect feedback and compare results from all panellists, noting any trends or differences in the evaluation.

19.4.9 EVALUATION CARDS:

Samples evaluation cards are an essential tool in sensory evaluation, providing a standardized method for panellists to record their perceptions and judgments about the samples they test. These cards allow sensory analysts to gather structured, consistent data that can be analyzed to make informed decisions about product quality and consumer preferences.

19.4.9.1 Importance of Evaluation Cards:

19.4.9.1.1 Standardization:

- Evaluation cards ensure that panellists use the same criteria and format to record their responses. This consistency is crucial for comparing results across panellists and sessions.

19.4.9.1.2 Clarity:

- They provide clear instructions for panellists, ensuring they understand what to evaluate and how to report their findings. This helps reduce confusion and increases the reliability of the data collected.

19.4.9.1.3 Objective Recording:

- By providing a structured format, evaluation cards help minimize subjective biases and ensure that all panellists assess the samples on the same sensory attributes.

19.4.9.1.4 Data Analysis:

- The structured nature of evaluation cards facilitates easy data entry and analysis, allowing sensory analysts to quantify the sensory characteristics and compare different products effectively.

19.4.9.2 Components of Evaluation Cards:

19.4.9.2.1 Sample Identification: Each sample should be assigned a random code to ensure blind testing. The sample identification section typically includes a space for the sample code (e.g., "A," "B," "C") without revealing any product names or details.

19.4.9.2.2 Sensory Attributes: The card should list the specific sensory attributes to be evaluated (e.g., appearance, aroma, flavor, texture). Each attribute may have a rating scale for panelists to indicate their level of agreement or perception (e.g., 1–9 scale, Likert scale).

- **Example Attributes:**
  - **Appearance:** Color, shape, uniformity
  - **Aroma:** Intensity, pleasantness, strength
  - **Taste:** Sweetness, sourness, saltiness, bitterness, umami
  - **Texture:** Smoothness, crunchiness, creaminess
  - **Overall Liking:** Panelists rate their overall impression of the sample.

19.4.9.2.3 Rating Scales: To quantify sensory responses, evaluation cards often use rating scales. Common scales include:

- **Hedonic Scale:** For preference or likability (e.g., 1 = dislike extremely, 9 = like extremely).
- **Descriptive Scale:** For specific sensory attributes (e.g., 1 = very weak, 5 = neutral, 9 = very strong).
- **Numeric Scales:** For quantifying characteristics such as intensity, bitterness, or sweetness.

19.4.9.3 Example of an Evaluation Card:

For a sensory evaluation of three different types of cookies, an evaluation card might include the following sections:

- **Sample Code**: Sample A, Sample B, Sample C
- **Sensory Attributes**:
  - **Appearance:**
    - 1 2 3 4 5 6 7 8 9 (Scale: 1 = very poor, 9 = excellent)

- **Aroma:**
  - 1 2 3 4 5 6 7 8 9 (Scale: 1 = very weak, 9 = very strong)
- **Taste:**
  - Sweetness: 1 2 3 4 5 6 7 8 9
  - Bitterness: 1 2 3 4 5 6 7 8 9
- **Texture:**
  - Crunchiness: 1 2 3 4 5 6 7 8 9
- **Overall Liking:**
  - 1 2 3 4 5 6 7 8 9 (Scale: 1 = dislike extremely, 9 = like extremely)

19.5 PANEL BOOTHS OR SENSORY BOOTHS:

Panel booths are an essential element of sensory evaluation, particularly when conducting tests that require controlled environments to minimize bias and external influence. A panel booth is a specially designed space where sensory panellists can evaluate food or beverage samples in an isolated and neutral setting. This controlled environment ensures that the sensory data collected is accurate and reflects the true qualities of the products being tested.

19.5.1 Importance of Panel Booths in Sensory Evaluation

19.5.1.1 Eliminating External Distractions: Panel booths help isolate panellists from any external distractions, such as noise, odors, or visual stimuli. This ensures that panellists can focus solely on the sensory attributes of the samples being evaluated.

19.5.1.2 Controlling Visual Influence: By using booths with minimal lighting and neutral colours, panellists are less likely to be influenced by the appearance of the samples, which could bias their taste perceptions. This helps ensure that the evaluation is based solely on sensory attributes like taste, smell, and texture.

19.5.1.3 Reducing Interaction between Panellists: Panel booths can prevent panellists from discussing the samples with one another during the evaluation. This isolation helps avoid social or cognitive biases that might arise if panellists influence each other’s opinions.

19.5.1.4 Maintaining Sample Integrity: With proper ventilation and controlled temperature, panel booths ensure that the samples maintain their original qualities without degradation due to environmental factors. For example, if the temperature is too high or too low, the sample's flavor and texture may be altered.

19.5.2 Key Features of a Sensory Panel Booth:

19.5.2.1 Privacy and Isolation: The primary design feature of a sensory panel booth is privacy. Each panelist is seated in an individual booth that isolates them from other panellists. This prevents any potential bias that could arise from seeing or hearing other panellists' reactions.

19.5.2.2 Neutral Design: The booth should be neutral in terms of color, furniture, and lighting. Bright or colourful designs could influence panellists' perceptions. Typically, booths are kept simple with a light gray or white color scheme to ensure that panellists' focus remains on the sample itself.

19.5.2.3 Comfortable Seating and Proper Table Setup: The booth should include comfortable seating that allows panelists to relax and focus on their evaluation. A small table is typically provided for the sample presentation, with enough space to accommodate the sample, a glass of water for palate cleansing, and any other necessary items.

19.5.2.4 Ventilation and Airflow Control: Proper ventilation is essential to prevent lingering odors from influencing the sensory evaluation. Panel booths should be equipped with an air filtration system that helps maintain fresh, neutral air quality.

19.5.2.5 Temperature Control: Temperature plays a significant role in sensory evaluation, and booths should be equipped with systems that maintain consistent, room-temperature conditions. For some tests, temperature control may be critical (e.g., serving a sample at the optimal temperature for flavor release).

19.6 SUMMARY:

The preparation, presentation, and controlled environment in which sensory evaluation takes place are all critical to obtaining reliable and accurate data. Proper sample preparation, along with the use of sensory panel booths, ensures that panellists can evaluate the products under optimal conditions, free from biases or distractions. When these factors are carefully controlled, sensory evaluations provide valuable insights that can inform product development, quality control, and consumer preferences.

19.7 TECHNICAL TERMS:

Sample Preparation, Presentation, Panel Testing, Panel booth, Environmental Control.

19.8 SELF ASSESSMENT QUESTIONS:

1) Explain the general requirements of sample preparation?
2) What are the steps involved in presentation of samples?

19.9 REFERENCES:

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LESSON-20

SENSORY TESTS-ANALYTICAL AND AFFECTIVE TESTS

OBJECTIVES:

After going through this lesson students will understand:

- To know about different types of sensory tests.
- To understand difference, rating, sensitivity and descriptive tests.

STRUCTURE:

20.1 INTRODUCTION:

Sensory evaluation tests are scientific methods used to measure, analyze, and interpret the sensory characteristics of products as experienced through the senses of sight, smell, taste, touch, and hearing. These tests help researchers and product developers ensure quality, understand consumer preferences, and innovate effectively. These tests provide critical insights into product quality, consumer preferences, and ingredient or process changes, making them indispensable tools in industries like food and beverage, cosmetics, and pharmaceuticals.

20.2 OBJECTIVES OF SENSORY EVALUATION TESTS:

- Quality Assurance: Ensure products meet established sensory standards.
- Product Development: Optimize sensory characteristics in new or reformulated products.

- Consumer Research: Identify consumer preferences to guide marketing and innovation.
- Competitive Analysis: Compare sensory attributes with competitors' products.
- Regulatory Compliance: Meet sensory specifications required by regulatory bodies.

20.3 TYPES OF SENSORY EVALUATION METHODS:

The sensory tests may be broadly classified into two major categories i.e.:

Analytical tests: Analytical tests are based on the evaluation of differences in clarity, quality and/or quantity of sensory characteristics of a product. The panelists for carrying out the analytical tests are screened for interest, ability to discriminate differences and reproduce results. They are trained to function as a human analytical instrument

Affective tests: Affective tests are based on the evaluation preferences and/or acceptance and/or opinions of product.

20.3.1 ANALYTICAL TESTS: Analytical tests are a cornerstone of sensory evaluation, focusing on the objective assessment of products to identify differences, similarities, and specific sensory attributes. These tests rely on the expertise of trained panelists to provide reliable and reproducible results. Analytical tests are crucial in product development, quality control, and research settings.

Types of Analytical Tests: Analytical tests are broadly classified into two categories: Discriminative Tests and Descriptive Tests**.**

20.3.1.1. DISCRIMINATIVE TESTS:

These tests are designed to determine whether a difference exists between two or more products. They are used to identify:

- Whether changes in ingredients, processes, or storage conditions affect the product.
- The detectability of small differences between samples.

Common Discriminative Tests: Discriminative tests, also known as difference tests, are used to determine whether a perceptible sensory difference exists between two or more products. They are simple, objective methods that help assess product consistency, detect changes due to reformulation, or evaluate the impact of processing or ingredient variations.

20.3.1.1.1. Difference Tests:

Objective: Determine if there is a perceptible difference between two or more samples at a statistically significant level.

A) Triangle Test: The Triangle Test is a commonly used discriminative method to determine if a perceptible sensory difference exists between two products. It is particularly useful for detecting small differences in product formulations, ingredients, or production methods.

i) Procedure:

1. Sample Presentation:

- Three coded samples are provided simultaneously to the panelist.
- Two of the samples are identical, and one is different.
- The samples are randomly arranged to avoid bias.

2. Task: The panelist must identify the odd sample (the one that differs from the other two).

3. Blinding: None of the samples is identified as the standard or control. This ensures that the panelist's judgment is solely based on sensory perception.

4. Panelist Selection: Panelists should be experienced or trained for better reliability.

ii) Applications of Triangle Test:

- Product Development: Evaluating the impact of new ingredients or processing methods.
- Quality Control: Ensuring consistency between production batches.
- Shelf-Life Testing: Assessing sensory changes during storage.
- Ingredient Substitution: Testing whether a replacement ingredient alters the sensory profile.

iii) Advantages:

- High sensitivity for detecting small differences.
- Simple to design and conduct.
- Requires fewer panelists compared to other discriminative methods.

iv) Limitations:

- Sensory fatigue: Testing three samples simultaneously may overwhelm the panelist.
- Not suitable for untrained panelists, as it may lead to random guesses.

The Triangle Test is a robust and versatile tool in sensory evaluation, offering insights into whether sensory differences exist between products, which can guide decisions in product development and quality assurance.

TRAINGLE TEST

Name : **Date :**

Product :

Two of the three samples are identical. Determine the odd sample .

Set No.	Code no.ofsamples	Code no.of odd samples	Comment on samples
I.			
II.			
III.			

Signature

B) Ranking Test: The Ranking test is a discriminative sensory evaluation method used to compare multiple samples based on a single sensory characteristic (such as sweetness, bitterness, or texture). This test is effective in determining the relative intensity of specific attributes across different products.

i) Procedure:

1) **Sample Presentation:** A set of samples, including a control or standard, is presented simultaneously to the panelists. All samples are coded to prevent bias. The number of samples can vary, but typically, 3 to 10 samples are evaluated based on the characteristic of interest.
2) **Task:** Panelists are asked to rank the samples from the weakest to the strongest or in order of preference, depending on the specific characteristic being assessed. The samples are ranked according to the perceived intensity of the characteristic (e.g., from the least to the most sweet, sour, or bitter).
3) **Control Sample:** A control (or standard) sample is usually included for comparison, providing a reference point for panelists.

ii) Applications of Ranking Test:

- **Product Development:** Identifying variations in attributes like flavor, texture, or aroma across multiple product formulations.
- **Quality Control:** Monitoring consistency in sensory characteristics across production batches.
- **Sensory Profiling:** Comparing the intensity of specific sensory characteristics (e.g., sweetness or bitterness) in different products, such as beverages or snacks.

iii) Advantages:

- Simple to conduct and understand, both for panelists and analysts.
- Efficient for comparing multiple samples in a single session.

RANKING TEST

Name : **Date :**

Product :

Please rank the samples in numerical order according to your preference or intensity of aroma/taste characteristic of the product.

Intensity/preference Sample code

I.

II.

III.

IV.

Signature

iv) Limitations:

- Requires panelists to differentiate between closely related samples, which can be challenging.
- Panelist bias may affect the ranking if not carefully controlled.

C) Duo-Trio Test: The Duo-Trio Test is a type of discriminative sensory evaluation used to determine if there is a perceivable difference between two products by comparing them to a known standard. It is particularly useful for identifying small differences in sensory attributes, such as flavor, roma or texture, between similar samples.

i) Test Procedure:

1) **Sample Presentation**: Three coded samples are presented to the panelist: One standard sample is provided first, which is identified as the reference. Two coded test samples follow, one of which is identical to the standard, while the other differs.

   The panelist does not know which of the test samples is identical to the standard.

2) **Task**: The panelist is asked to identify which of the two coded samples matches the standard sample in terms of sensory characteristics (such as taste, texture, or aroma). The correct identification of the sample that matches the standard indicates the ability of the panelist to detect differences between the samples.

3) **Blinding**: All samples are coded to prevent bias, and the standard sample is presented first to provide a clear point of reference.

DUO-TRIO TEST

Name : **Date :**

Product :

The first sample R given is the reference sample.

Taste it carefully

From the pair of coded sample next given , judge which sample is the same as R .

Set No.	**Code No.of Pairs**	**same as 'R'**
I.		
II.		
III.		
IV.		

Signature

ii) Applications of the Duo-Trio Test:

- Product Development: Identifying subtle differences between formulations or ingredients to fine-tune recipes.
- Quality Control: Ensuring consistency in the sensory characteristics of a product across batches or over time.
- Ingredient Testing: Assessing the impact of ingredient changes or substitutions on the final product's sensory profile.

iii) Advantages:

- Clear Benchmark: Having a standard reference sample makes it easier for panelists to focus on the differences between the coded samples.
- Simple and Effective: The test is straightforward to perform, and the results are relatively easy to interpret.
- Reliability: Panelists' ability to detect differences is enhanced by the inclusion of a known reference, leading to more accurate responses.

iv) Limitations:

- Panelist Sensitivity: Results depend on the ability of the panelists to discern subtle differences. Highly trained panelists are typically required for more reliable outcomes.
- Bias: Since the panelist is provided with a standard sample, there may be some bias in identifying the correct match, particularly if the difference between the samples is minimal.

D) Paired Comparison Test: The Paired Comparison Test is a simple and commonly used method in sensory evaluation to detect and compare differences between two samples based on specific sensory characteristics. This test helps in both discriminating differences and determining preferences for particular attributes such as flavor, aroma, or texture.

i) Test Procedure:

1) **Sample Presentation**: Two coded samples are presented to the panelist, either simultaneously or sequentially, depending on the test design. The samples are typically coded to prevent any bias due to preconceived notions about the products.
2) **Task**: In a simple difference test, panelists are asked to determine whether the two samples in each pair are the same or different**.** In a directional difference test, panelists are asked to indicate which of the two samples has the greater or lesser intensity of a specific sensory attribute (e.g., which sample is sweeter, saltier, or more bitter).

3) **Balanced Order of Presentation**: To avoid bias based on the order of presentation, the sequence in which the samples are presented is often balanced, ensuring that each sample appears equally in the first or second position across panelists.

ii) Types of Paired Comparison Tests:

1) **Simple Difference Test**: This test is used to determine if there is a perceptible difference between the two samples in terms of a particular sensory characteristic. The panelist simply judges whether the two samples are the same or different.

2) **Directional Difference Test**: In this version, the panelist not only identifies whether the samples are different but also determines which one has a greater or lesser degree of intensity for a specified characteristic (e.g., which sample is more acidic, sweet, or salty).

iii) Applications of Paired Comparison Test:

1) **Product Development**: To assess whether a new product or formulation differs from an existing product or control sample.

2) **Quality Control**: To determine if any batch variations or changes in processing affect the sensory attributes of the product.

3) **Preference Testing**: When used in consumer testing, the Paired Comparison Test helps identify which product is preferred based on a specific sensory characteristic, such as flavor or texture.

4) **Panel Training**: The test can also be used to train panelists in sensory analysis by helping them develop their ability to discern differences in sensory attributes.

iv) Advantages:

1) **Simplicity**: The Paired Comparison Test is easy to implement and understand, making it ideal for both beginners and experienced panelists.

2) **Effective for Simple Comparisons**: It is particularly useful when the goal is to detect whether there is a difference between two samples or to measure the intensity of a sensory attribute.

3) **Versatility**: It can be used in a wide range of sensory evaluations, including product testing, preference testing, and training.

v) Limitations:

1) **Limited to Two Samples**: The test only compares two samples at a time, which may not capture the full range of possible variations in sensory characteristics if more products need to be compared.

2) **Panelist Sensitivity**: The accuracy of the results relies on the ability of the panelists to detect small differences, and their sensitivity can influence the outcome of the test.

3) **Bias Due to Order**: Even with balanced presentation orders, there could still be subtle biases introduced by the order in which the samples are presented.

PAIRED COMPARISON TEST

Name : **Date :**

Product :

You are given one or several pairs of sample. Evaluate the two samples in the pair for …… Is there any difference between the two samples in the pair?

Code no. of pairs **Yes** **No** **Signature**

20.3.1.1.2: SENSITIVITY TESTS:

Sensitivity tests are designed to evaluate the ability of individuals to detect sensory characteristics in a product. These tests measure the sensory acuity of panelists in terms of their ability to perceive differences in intensity, detect thresholds, and identify sensory attributes. Sensitivity tests are essential in panelist training and for understanding human sensory capabilities.

20.3.1.1.2.1: Types of Sensitivity Tests

A) Threshold Test:

a) Determines the minimum level of a sensory stimulus (e.g., sweetness, bitterness, saltiness) that a panelist can perceive.

b) Tests both the detection threshold (minimum level at which a stimulus is detected but not identified) and the recognition threshold (minimum level at which the stimulus can be identified).

B) Dilution Test:

a) Used to determine the lowest concentration of a substance that is still perceivable by the panelist.

b) This test is often used in flavor analysis, such as detecting the presence of specific compounds in food or beverages.

C) Difference Threshold Test:

a) Measures the smallest change in intensity of a sensory attribute that a panelist can detect.

b) Also known as the just noticeable difference (JND) test.

D) Ranking Sensitivity Test:

a) Panelists rank samples based on the intensity of a particular sensory characteristic, such as sweetness or bitterness.

b) This test is used to evaluate the sensitivity of panelists in distinguishing varying intensities.

E) Triangle Sensitivity Test:

a) Panelists are presented with three samples: two are identical, and one is different.

b) The task is to identify the odd sample, testing the panelist's ability to discriminate sensory differences.

E) Forced-Choice Test:

a. Panelists are presented with samples and are forced to choose which sample has a particular characteristic (e.g., "Which sample is sweeter?"). This test evaluates specific sensitivity to a defined attribute.

20.3.1.2: DESCRIPTIVE TESTS:

Descriptive tests are used to identify and quantify the sensory characteristics of a product. These tests provide detailed sensory profiles by evaluating attributes such as appearance, aroma, taste, texture, and even sound. Unlike discriminative tests, which focus on detecting differences, descriptive tests delve deeper into the qualitative and quantitative aspects of sensory attributes.

20.3.1.2.1: Methodologies in Descriptive Tests:

Descriptive tests typically rely on two primary methodologies:

A) Qualitative Descriptive Analysis (QDA):

- Focuses on identifying and describing all sensory attributes of a product.
- Panelists use sensory descriptors to create a detailed profile.
- Attributes are not rated for intensity in this method, but rather listed and defined.

Example: Describing the aroma profile of coffee as having notes of "nutty," "earthy," and "chocolate."

B) Quantitative Descriptive Analysis (QDA):

- Combines qualitative descriptions with quantitative intensity ratings.
- Panelists evaluate the intensity of sensory attributes using a standardized scale (e.g., 0-15 on a line scale).
- Results are often presented as spider or radar plots to visually depict sensory profiles.

- Example: Measuring the sweetness intensity of a beverage on a scale of 0 (none) to 15 (very sweet).

20.3.2 AFFECTIVE (PREFERENCE AND ACCEPTANCE) TESTS:

Affective Tests are sensory evaluation methods focused on measuring preferences and acceptance of a product based on consumers' subjective responses. These tests are used extensively in product development and market research to gauge consumer attitudes and satisfaction.

20.3.2.1 Key Concepts:

A) Preference:

a) Definition: Refers to an individual's expression of a higher degree of liking for one product over another.

b) Types:

i) Higher Degree of Liking: Consumers indicate their level of preference on a scale (e.g., "like extremely" to "dislike extremely").

ii) Choice**:** Consumers select one product over others presented to them.

B) Acceptance:

a) Definition: Reflects a consumer's positive attitude toward a product and/or its actual usage.

b) Attributes: Evaluates emotional response (e.g., pleasure-displeasure). Often includes measures of usability or fit with the consumer's needs.

c) Measurement: Typically inferred from scale ratings indicating how much the consumer likes or is willing to use the product.

20.3.2.2 Types of Affective Tests:

20.3.2.2.1 Paired-Performance Test:

- **Purpose**: Direct comparison of two products to determine which is preferred for a specific attribute.
- **Method**: Participants are presented with two samples and choose the one they like better.
- **Application**: Common in early-stage product development to identify preference trends.

20.3.2.2.2 Ranking Test:

- **Purpose**: To rank multiple samples based on preference.
- **Method**: Participants are provided with several samples and asked to rank them from most to least preferred.

- **Application**: Useful when there are more than two products and developers need a relative preference order.

20.3.2.2.3 Rating Scale Test:

- **Purpose**: To measure the degree of liking or disliking for a product.
- **Method**: Participants evaluate products on a numerical or descriptive scale (e.g., a 9-point hedonic scale: "like extremely" to "dislike extremely").
- **Application**: Widely used to assess product acceptability in terms of flavor, texture, appearance, etc.

Scale ratings reflect panelist's perceived intensities of a specified attribute under a given set of conditions. Various rating scales have been developed and used:

A) Hedonic Rating Scale: The Hedonic Rating Scale is a widely used method in sensory evaluation to measure the level of liking or disliking for food and other consumer products. It is particularly useful for gauging consumer preferences and acceptance within a population. Several variations of the traditional nine-point hedonic scale have been used effectively. These include:

- **Reduced Categories**: Ideal for quick surveys or when testing involves a diverse population.
- **Expanded "Like" Categories**: Useful in differentiating high-performing products in competitive markets. A six-point scale with more "like" options, such as:

1) Dislike very much □
2) Dislike slightly □
3) Like slightly □
4) Like moderately □
5) Like very much □
6) Like extremely □

- **Facial Hedonic Scale**: Best suited for young children, populations with limited literacy, or multicultural groups.

  Example: Faces depicting the following:
  □ →Dislike extremely → □ Neutral → □ Like moderately → □ Like extremely

- **Line Scale**: Preferred when detailed and nuanced responses are required, such as in product optimization studies. Each variation enhances the versatility of the Hedonic Rating Scale, ensuring its effectiveness across different test scenarios and participant groups.

B) Food Action Scale Rating (FASR): The Food Action Scale Rating is a sensory evaluation method used to assess the general acceptance of a food product by a population. Unlike other methods focused on specific attributes, this scale captures the overall attitude toward a product through action-oriented and affective statements.

EXAMPLE OF EVALUATION FOR A SOFT DRINK

Acceptance Test Categories

Taste:

Water-like

Strongly sweet

Sweet

Salty

Strongly salty

Medicinal

Viscosity:

Less viscous (e.g., water-like)

Highly viscous (e.g., honey-like)

Consistency:

Homogeneous

Heterogeneous

Panelists assess the soft drink using these attributes and indicate their general attitude on the FASR scale.

20.4 SUMMARY:

Sensory testing plays a crucial role in evaluating the properties of food, beverages, cosmetics, and other consumer products. It helps understand how these products are perceived by human senses and provides valuable feedback for product development, quality control, and marketing. Sensory tests can be broadly categorized into analytical tests and affective tests.

Understanding the strengths and purposes of both analytical and affective sensory tests is crucial for businesses aiming to create products that meet both quality standards and consumer expectations. Integrating these methods provides comprehensive insights, guiding innovation and ensuring market success.

20.5 TECHNICAL TERMS:

Sensory Analysis, Sensory Methods, Flavor, Texture.

20.6 SELF ASSESSMENT QUESTIONS:

1. Explain the types of Sensory evaluation?
2. What is an Affective test and what are the types of affective tests?

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