DEPARTMENT OF FOOD CHEMISTRY AND NUTRITION

STUDY MATERIAL

Course Title: Food Chemistry of Macronutrients Course No: FDCN - 231 Credits: 3(2+1)

> Prepared by MS.B. Sunitha Teaching Associate, CFST, Bapatla and Mrs.R. Aruna Asst. Professor, CFST, Pulivendula



ACHARYA NG RANGA AGRICULTURAL UNIVERSITY COLLEGE OF FOOD SCIENCE & TECHNOLOGY BAPATLA -522 101

Theory Lecture Outlines

- 1. Food chemistry Definition, Introduction, Importance and History of Food Chemistry
- 2. Moisture in foods Role and type of water in foods
- Water activity and sorption isotherm Role of water activity in enhancing the shelf life of foods - Hysteresis - Humectants - Role of Humectants in enhancing the shelf life of foods
- 4. Dispersed systems of foods Colloidal system Types of colloidal system
- 5. Sols Types of sols, lyophilic sols, lyophobic sols, Preparation, purification and Properties of sols
- 6. Gels-Types of Gels, properties of gels, Food gels
- 7. Emulsions Types of emulsions, Preparation and properties of emulsions
- 8. Foam Formation and structure
- 9. Changes of carbohydrates on cooking Changes in pectic substances, Changes in starch
- 10. Reactions involved in food processing
- 11. Starch Starch granules, Granule gelatinization (Gelatinization of starch), Hydrolysis of starch, Crude fibre
- 12. Browning reactions Enzymatic browning and non enzymatic browning
- 13. Functional properties of sugars
- 14. Pure proteins of plant and animal origin with their functional characteristics
- 15. Plant proteins cereal proteins, tuber proteins and pulse storage proteins
- 16. Milk proteins Casein, whey proteins and colostrums
- 17. Egg proteins Egg white proteins, Egg yolk proteins
- 18. Lipids Introduction Fatty acids, Acyl glycerols, Phospholipids
- 19. Classification of edible fats Milk fats, lauric acids, vegetable butters, oleic-Linoleic acids, linolenic acids, Animal fats, Marine oils
- 20. Physical aspects of lipids Crystallization, Consistency
- 21. Chemical aspects of lipids Lipolysis, Auto-oxidation, Thermal decomposition, polymerization
- 22. Edible fats and oils Melting properties, chemical properties
- 23. Technology of edible fats and oils Rendering, pressing, solvent extraction
- 24. Chemistry of fat and oil processing : Refining, Hydrogenation, Interesterification
- 25. Frying technology of edible fats and oils Chemistry of frying, Behaviour of frying oil

- 26. Behaviour of food during frying, chemical and physical changes, Tests for assessing the quality of frying oils
- 27. Anti-oxidants-Natural and synthetic anti oxidants, Mechanism of action, examples and mode of application
- 28. Rancidity and its types, detection techniques
- 29. Enzymes in food industry Carbohydrases- Amylases, pectin lytic enzymes, cellulases and hemi cellulases
- 30. Proteases Endo peptidases, Metalo peptidases
- 31. Lipid hydrolyzing enzymes Lipases, Phospho lipases
- 32. Chemical reactions of interest to food processing

Lecture No: 1

Food chemistry – Definition, Introduction, Importance, History of Food chemistry.

Definition:

Food chemistry, a major aspect of Food science , deals with the composition and properties of food and chemical changes it undergoes during handling, processing & storage.

Importance :

Food chemistry is intimately related to chemistry, biochemistry, physiological chemistry, botany, Zoology and molecular biology. The food chemistry relies heavily on knowledge of the aforementioned scientist to effectively study and control biological substances as a sources of human food. In control food chemistry is concerned primarily with biological substances that are dead or dying and changes they undergo where they exposed to a very wide range of environmental condition. In addition, food chemistry is concerned with the chemical properties of disrupted food tissues, single cell sources of food and major biological fluid, milk.

History of food chemistry:

During the period of 1780 – 1850 a number of famous chemists made important discoveries, many of which directly or indirectly related to the chemistry of food.

Carl Wilhelm Scheele: (1742 – 1786) a Swedish pharmacist was one of the greatest chemists of all time. In addition to his famous discoveries of chlorine, glycerol and oxygen isolated citric acid from lemon juice (1785), isolated Malicacid from apples (1785) and tested 20 common fruits for the presence of citric, malic & tartaric acid (1785).

The French chemist Antonie Laurent Lavoiser (1743 - 1794) was instrumental in the final rejection of the phlogiston theory and in formulating the principles of modern chemistry.

Theodore de Saussure a French chemist, did much to formalize and clarity the principles of agricultural and Food chemistry provided by Lavoiser.

The English chemist sir Humphrey Davy (1778 – 1829) in the years 1807 and 1808 isolated the elements K, Na, Ba, Ca and Mg.

The works of Swedish chemist Jons Jacob Berzelius (1779 - 1848) and the Scottish chemist Thomas Thomson (1773 - 1852) resulted in beginning of organic formulas.

It is interesting that the development just reviewed paralleled the beginning of serious and widespread adulteration of food.

The early 1800's was a period of especially intense public concern over the quality and safety of the food supply. Thus during the period of 1820 – 1850 chemistry and food chemistry began to assume importance in Europe.

During the first half of 20th century most of the essential dietary substance are discovered and in 19th century chemicals to aid in growth, manufacture & marketing of foods is discovered & current food supply seems almost perfect in comparison to which exist in 1800's.

Lecture No: 2

Moisture in foods :Role and type water in foods

The most abundant compound, and the one which is almost always present in foods is water. Occasional a food such as an oil will be dry; but even crystallized substances which are relatively pure, such as sugar and salt, contain small amounts of water absorbed on the surfaces of the crystals. Cellular material, whether plant or animal contains an abundance of water. In leafy green vegetables there is 900 more percent water, while even in cooked meat where some water has been driven off the amount is between 50 and 65%.

The water which is present in foods may be held as

- 1. As a free liquid in which substances are dissolved & dispersed
- 2. As hydrates
- 3. As imbibed water in gels
- 4. By absorption on the surfaces of solids.

Examples of the first type are found in cytoplasm intracellular fluid and any of the circulating fluids of tissue. In the second type, hydrates form either when hydrogen bonds are established between water molecules and ions or molecules which contain oxygen or nitrogen or when the unshared electrons of the oxygen ore nitrogen or when the unshared electrons of the oxygen are coordinated with an ion starches. Proteins and many other organic compounds important in foods as well as salts, form hydrates. Imbibed water may not be different from water held as a hydrate. Some substances pick up water and swell when they come in contact with water. The fourth type of water is held on all surfaces exposed to air in which water vapour is present "Dry" coca holds water and air on the surface of the particles. Solids which are very finely divided have a very large surface area and consequently have a high adsorptive capacity.

Classification	Name	Moisture
Food grains	Rice, Wheat, Jowar	12 – 13
Dals, Pulses	Tur & Mungdal, chawali	10 - 13
Nuts, oilseeds	Groundnut, sesame, Mustard	3 – 8
Sugar	Jaggery, sugar	4 – 0.4
Oils, Fats	Butter & Ghee, oil, vanaspati	19 & 0
Fruits fresh	Tomato & Banana	94 & 70
Fruits, Dry	Apricots, Raisins, dates	15 - 20
Vegetables		
Leafy vegetables	Cabbage, spinach	92
Roots, tubers	Таріоса	60
	Radish	95
Others	Cucumber, pumpkin	92 – 96
	Double beans	74
Animal foods	Milk, cows	88
	Eggs	74
	Fish, pomfrets	75
	Poultry, fowl	72
	Meat, Mutton	7

Moisture content of Foods

Role and Type of Water in Foods

Water is most abundant substance in plant and animal matter. The water content of animals and plant varies widely.

Water content in foods :

Water is as much a part of all, foods as a carbohydrates, fats and proteins. Cellular material contains a abundance of water. In leafy green there is 90% or more fruits and vegetables contain plenty of moisture to the extent of 70, 80 percent. Water, which is present in foods, may be held as

- 1. Free water
- 2. Bound water

Free water is present in cells, and in circulating fluids of tissues as in cell sap. It contains dissolved and dispersed solutes in the cell. It is easily lost by drying the food.

The bound water in foods is held by proteins polysaccharides and fats in the living cells. Bound water may also be absorbed on the surfaces of solids in foods. The removal of bound water from tissues is very difficult. Bound water is resistant to freezing and chilling.

Role in Food Preperation :-

The role of water in food preparation is of great importance.

As a cooking medium:-

This is perhaps the most common and important its many uses in cookery. Water has been universally used as a medium of cooking. The ubiquitous nature of water, its free availability and its low cost of supply are some of the factors which influence the use of water as a cooking medium.

Dry foods absorb water and swell before they get cooked. Water acts as a medium of heat transfer from the surface area to the different parts of the food. Therefore foods which have moisture content take a longer time than foods with greater moisture content.

As a solvent :-

Water is a universal solvent for many food substances. Water not only dissolve flavours, but also colour pigments in fruits and vegetables like anthocyanins and odours. Thus the solvent action of water is responsible for the palatability of the food cooked in it.

Water absorption :-

Dry foods cooked in water absorb water, expand in volume and increase in weight. Foods like cereals and pulses when cooked water, gain weight to the extent of 2 - 3 times. Therefore the nutrients supplied per unit weight are diluted to that extent.

Water also functions in food preparation as a dispersing medium and helps to produce smooth texture. It helps to distribute particles of materials like starch and protein. When flour is used to thicken liquids, the particles need to be dispersed through out the liquid phase as in a starch gel.

Dry foods like cereals, millets, pulses are generally first soaked for a period of time before they are cooked as they take a longer time to cook than foods with a greater moisture content. This helps to decrease the cooking time, very often rice, dals and legumes are cooked under pressure to hasten the cooking process.

Water acts as a leavening agent in food preparations. When batters and doughs are exposed to heat the water present is converted to steam. The steam expands and is response for the leavening effect.

Keeping Quality of Foods :-

The shelf-life or storage period of food is greatly influenced by its moisture content. Water is essential for the growth of microorganisms. In the presence of enough moisture, microorganisms multiply. It some of these are harm then they will render the food inedible.

Therefore on the basis of their stability during storage, foods can be divided into 3 categories.

- 1. Non-perishable
- 2. Semi perishable
- 3. Perishable
- Non-perishable :- It may be noted that cereals, dals and legumes with a moisture content below 13 percent are nonperishable if stored in a cool, dry place. It is important to store dry foods like sugar, salt, coffee powder in very dry containers. For these foods pick up moisture readily from the atmosphere and may deteriorate.
- 2. Semi perishable foods can be stored for a week to a month at room temperature without any undesirable change in flavor or texture Eg: biscuits, roasted chana dal etc.

3. Perishable foods :-

Which have high moisture content can be kept only for a short period. They have to be stored at refrigeration temperature, if their shelf life is to be perishable.

Eg: milk, paneer, meat, fresh fruits & vegetables.

Texture and consistency :-

The amount of moisture present in food stuffs affects its texture consistency & feel in the mouth softer foods & liquid foods are

swallowed easily, while crisper and drier foods are more difficult to swallow.

Body Needs:-

Water is an essential nutrient next only in importance to oxygen. Deprivation of water even for a few days can lead to death. An adult man need about 1.0-1.5 litres of water per day, in addition to the moistures content contained in foods, eaten.

Lecture No: 3

Water Activity and Sorption Isotherm

Water Activity :-

In 1952, Scott came to the conclusion that the storage quality of food does not depend on the water content but on water activity (a_w)

$$A_{w} = P \qquad E_{RH}$$
$$P_{0} \qquad 100$$

Where

 E_{RH} = Equilibrium relative humidity

P = Partial vapour pressure

P₀ = Saturation vapour pressure

Relation between water content and water activity is indicated by sorption isotherm of food. At low water content (<50%) minor changes in this parameter lead to major changes in water activity. It is shown in figure



In figure (b) the desorption isotherm, indicating the course of a drying process lies slightly above the adsorption isotherm pertaining to the storage of moisture sensitive food.

Decreased water activity retards the growth of micro organisms, slow enzyme catalyzed reactions and lastly retards non enzymatic browning. Foods with a_w values between 0.6 and 0.9 are known as "Intermediate Moisture Foods" Those foods are largely protected against microbial spoilage.

Sorption Isotherm :-

The relationship between water activity and water content is indicated by sorption isotherm of food.

At low water content (<50%) even minor changes in this parameter lead to major changes in water activity.

The water activity has both adsorption or resorption. Similarly like to the adsorption, desorption is also present. Resorption means addition of water to the previously dried samples.



Lecture No: 4

Dispersed system of Foods – Colloidal system and type of colloidal system.

Dispersed system of Foods:-

Thomas Graham studied the ability of dissolved substances to diffuse into water across a permeable membrane. He observed that crystalline substances such as sugar, urea and sodium chloride passed through the membrane while others like glue, gelatin and gum Arabic did not. The formers be called crystalloids and the later colloids. Graham thought that the difference in the behavior of crystalloids and colloids was due to the particle size. Later it was realized that any substrate regardless of its nature could be converted into a colloid by subdividing it into particles of colloidal size.

Colloids :-

In a true solution as sugar or salt in water the sow particles are dispersed in the solvent as single molecules or ion. Thus the diameter of the dispersed particles ranges from 1A to $10A^{0}$.

On the other hand, in a suspension as sand stirred into water, the dispersed particles are aggregates of millions of molecule. The diameter of these particles is of the order of 2000 or more



The colloidal systems or colloidal dispersions are intermediate between true solutions and suspensions. In other words, the diameter of the dispersessd particles in a colloidal dispersion is more than that of solute particles in a true solution and smaller than that of suspension.

When the diameter of the particles of a substance dispersed in a solvent ranges from about $10A^0$ to $2000A^0$. The system is termed a colloidal solution, colloidal dispersion or simply a colloid. The

material with particle size in the colloidal range is said to be in colloidal state.

A system with at least one dimension of the dispersed particles in the range $10A^0 2,000 A^0$, is classed as a colloidal dispersion.

Types of colloidal systems:-



As we have seen above, a colloidal system is mode of two phases. The substance distributed as the colloidal particles is called the dispersed phase. The second continuous phase in which the colloidal particles are dispersed is called dispersion medium. For example for a colloidal solution of copper in water, copper particles constitute the dispersed phase and water the dispersion medium.

As stated above, a colloidal system is made up of a dispersed phase and dispersion medium. Because either the disperse phase or the dispersion medium can be a gas liquid or solid. There are 8 types of colloidal systems possible. A colloidal dispersion of or gas in another is not possible since two gases would give a homogenous molecular mixture.

The colloidal systems which consists of a solid substance dispersed in a liquid referred to as sols or colloidal solutions. The colloidal solutions in water as a dispersion medium are termed hydrosols or Aqua sols. When the dispersion medium is alcohol or benzene the sols are referred as Alco sols and Benz sols respectively.

Types of colloidal systems :-

Type name	Dispersed	Dispersed	Examples
	phase	Medium	
Foam	Gas	Liquid	Whipped
			cream,
Solid foam	Gas	Solid	Sharing cream.
			Foamrobby,
Aerosol	Liquid	Gas	cork
			Clouds, fog
Emulsion	Liquid	Liquid	
			Milk
Solid Emulsion	Liquid	Solid	Butter, cheese
Smoke	Solid	Gas	Dust, soot in
			hair
Sol	Solid	Liquid	Paint, Ink
Solid sol	solid	solid	Ruby glass,
			Alloy

Lecture No: 5

Sols – Types of sols, preparation, purification and properties of sols

Sols :- Sols are colloidal systems in which a solid is dispersed in a liquid. These are subdivided into two classes

- a. Lyophilic sols (solvent loving)
- b. Lyophobic sols (solvent hating)

a. Lyophilic sols :-

Lyophilic sols are those in which the dispersed phase exhibits a definite affinity of the medium or solvent. Examples :- Dispersions of starch gum and protein in water

b. Lyophobic sols :-

Lyophobic sols are those in which the dispersed phase has no attraction for the medium or the solvent.

Examples :- Gold, iron III hydroxide and sulphur in water.

The affinity or attraction of the sol particles for the medium in a lyophilic sol, is due to hydrogen bonding with water. If the dispersed phase is a protein (as in egg) hydrogen bonding takes place between water molecules and amino groups (-NH -, -NH₂) of the protein molecule. In a dispersion of starch in water, hydrogen bonding occur between water molecules and the – OH groups of the starch molecule. There are no similar forces of attraction when sulphur or gold is dispersed in water.

Characteristics of lyophilic and lyophobic sols :-

Some features of lyophilic and lyophobic sols are listed below

1. Ease of preparation :-

Lyophilic sols can be obtained straightway by mixing the material with a suitable solvent. Lyophobic sols are not obtained by simply mixing the solid material with solvent.

- 2. **Charge on particles**:- Particles of a hydrophilic sol may have a little no charge at all. Particles of a hydrophobic sol carry positive or negative charge which gives them stability.
- 3. **Solvation** :- Hydrophilic sol particles are generally solvated. Hydration of gelatin is an example. There is no salvation of the hydrophobic sol particles for want of interaction with the medium.

- Viscosity :- Lyophilic sols are viscous as the particle size increase due to salvation Eg: Preparation of jelly. Viscosity of hydrophobic sol is almost same as of the dispersion medium itself.
- 5. **Precipitation** :- Lyophilic sols are precipitated (or coagulated) only by high concentration of the electrolytes when the sol particles are desolvated. Lyophobic sols are precipitated even by low concentration of the electrolytes, the protective layer is absent.
- 6. **Reversibility** : The dispersed phase of lyophilic sols when separated by coagulation or by evaporation of the medium can be reconverted into colloidal form just on mixing with the dispersion medium. Therefore this type of sols are designated as Reversible sols.

On the other hand, the lyophobic sols once precipitated cannot be reformed merely by mixing with dispersion medium. These are, therefore called Irreversible sols.

7. **Tyndall effect:-** On account of relatively small particles size lyophilic sols do not scatter light and show tyndall effect.

Lyophobic sol particles are large enough to exhibit Tyndall effect.

8. Migration in Electric field :-

Lyophilic sol particles (proteins) migrate to anode cathode, or not at all when placed in electric field.

Lyophobic sol particles move either to anode or cathode according as they carry negative or positive charge.

Comparison of Lyophilic and Lyophobic sols :

Lyophobicsols
1. Not prepared by direct
mixing with the
medium
2. Particles carry positive
or negative charge.
3. No salvation of particles
4. Viscosity almost the
same as a medium; do
not set to a gel.
5. Precipitated by low
concentration of
electrolytes.
6. Irreversible
7. Exhibit tyndall effect
8. Particles migrate to
anode or cathode.

Preparation of Sols :-

Lyophilic sols may be prepared by simply warming the solid with the liquid dispersion medium

Eg. Starch with water

Lyophobic sols have to be prepared by special method. These methods fall into two categories.

- a. Dispersion Method
- b. Aggregation Method

a. Dispersion Methods :-

In this method larger macro –sized particles are brown down to colloidal size and material in bulk is dispersed is another medium.

1. Mechanical dispersion using colloidal mill :-

The solid along with the liquid dispersion medium is fed into a colloid mill. The mill consist of two steel plates nearly touching each other and rotating is opposite directions high speed. The solid particles are ground down to colloidal size and are then dispersed in the liquid to give the sol. Colloidal graphite (a lubricant) and printing inks are made by this method.

Recently, mercury sol has been prepared by disintegrating a layer of mercury into sol particles in water



2. Bredig's Arc Method :-

It is used for preparing hydrosols of metals Eg: silver, gold and platinum. An arc is stock between the two metal electrodes held close together beneath deionized water. The water is kept cold by immersing the contains in ice or water bath and a trace of alkali (KOH) is added. The intense heat of spark across the electrodes vaporizes some of the metal and the vapour condenses under water. Thus the atoms of the metal present in the vapour aggregate to form colloidal particles in water. Since the metal has been ultimately converted into sol particles this method has been treated as of dispersion.

Non-metal sols can be made by suspending coarse. Particles of the substance in the dispersion medium and striking an are between iron electrodes.



By Peptization :

Some freshly precipitated ionsic solids are dispersed into colloidal solution in water by the addition of small quantities of electrolytes, particular those containing a commotion. The precipitate absorbs the common ions and electrically charged particles the split from the precipitate as colloidal particles.

The dispersal of a precipitated material into a colloid solution by the action of an electrolyte in solution, is termed peptization. The electrolyte used is called peptizing agent.

Peptization is the reverse of coagulation of a sol. Examples preparation of sols by peptization.

- 1. Silver chloride, Ag⁺ Cl⁻, can be converted into a sol by adding hydrochloric acid (Cl⁻ being common ion).
- 2. Ferric hydroxide, $Fe(OH)_3$, yields a sol by adding ferric chloride (Fe^{3+} being common ion).

Aggregation Methods :-

These methods consist of chemical reactions change of solvent where by the atoms or molecules of the dispersed phase appearing first, coalesce or aggregate to form colloidal particles. The conditions used are such as permit the formation of sol particles but prevent the particles becoming too large and forming precipitate. The unwanted to (spectator ions) present in the sol are removed yb dialysis as these ions may eventually coagulate the sol.

The more important methods for preparing hydrophobic sols are listed below.

1. Double Decomposition :-

An arsenic sulphide (AS_2S_3) sol is prepared by passing a slow stream of hydrogen sulphide gas through a cold solution of arsenious oxide (AS^2S^3) . This is continued till the yellow colour of the sol attains maximum intensity

 $AS_2O_3 + 3H_2S \longrightarrow AS_2S_3 (sol) + 3H_2O$ Yellow

Excess hydrogen sulphide (electrolyte) is removed by passing in a stream of hydrogen.

2. Reduction :-

Silver sols and gold sols can be obtained by treating dilute solutions of silver nitrate or gold chloride with organic reducing agents like tannic acid or ethanol (HCHO)

AgNO ₃ + tannic acid	Ag sol
AuCl ₃ + tannic acid	Au sol

3. Oxidation :-

A sol of sulphur is produced by passing hydrogen sulphide into a solution of sulphur dioxide.

2H₂S + SO₂ → 2H₂O + S ↓

In qualitative analysis sulphur sol is frequently encountered when H_2S is passed through the solution to precipitate group 2 metals if an oxidizing agent (chromate or ferric ions) happen to be present. It can be removed by boiling (to coagulate the sulphur) and filtering through two filter papers folded together.

4. Hydrolysis :

Sols of the hydroxides of iron, chromium and aluminum are readily prepared by the hydrolysis of salts of the respective metals. In order to obtain a red sol of ferric hydroxide, a few millilitres of 30% ferric chloride solution is added to a large volume of almost boiling water and stirred with a glass rod.

 $Fed_3 + 3H_2O \longrightarrow Fe(Oh)_3 + 3Hcl$ red_{sol}

5. Change of solvent :-

When a solution of sulphur or resin in ethanol is added to an excess of water, the sulphur or sol is formed owing to decrease in solubility. The substance is present in molecular state in ethanol but on transference to water, the molecules precipitate out to form colloidal particles.

Purification of sols :-

In the methods of preparation stated above the resulting sol frequently contains besides colloidal particles appreciable amounts of electrolytes. To obtain the pure sol, these electrolytes have to be removed. This purification of sols can be accomplished by three method.

- a. Dialysis
- b. Electro dialysis
- c. Ultra filtration
- a. **Dialysis** :- Animal membranes (bladder) or those made of parchment paper and cellophane sheet, have every fine pores. These pores permit ions(or small molecules) to pass through but not the large colloidal particles. When a sol containing dissolved ions (electrolyte) or molecules is placed is a bag of permeable membrane dipping in pure water the ions diffuse through the membrane. By using a continuous flow of fresh water, the concentration of the electrolyte outside the membrane tends to be zero. Thus diffusion of the ions into pure water remains brisk all the time. In this way, practically all the electrolyte present in the sol can be removed easily.

The Process of removing ions (or molecules) from a sol by diffusion through a permeable membrane is called Dialysis. The apparatus used for dialysis is called dialyser. Example :- A ferric hydroxide sol (red) made by the hydrolysis of ferric chloride will be mixed with some hydrochloric acid. If the impure sol is placed in the dialysis bag for sometime the outside water will give a white precipitate with silver nitrate. After a pretty long time, it will be found that almost the whole of hydrochloric acid has been removed and the pure red sol is left is the dialyses bag.

b. Electro dialysis :

In this process, dialysis is carried under the influence of electric field. Potential is applied between the metal screens supporting the membranes. This speeds up the migration of ions to the opposite electrode. Hence dialysis is greatly accelerated. Evidently Electro dialysis is not meant for nonelectrolyte impurities like sugar and urea.



c. Ultra filtration :-

Sols pass through an ordinary filter paper. Its pores are too large to retain the colloidal particles. However, if the filter paper is impregnated with colloidan or a regenerated cellulose such as cellophane or visking the pore size is much reduced such a modified filter paper is called an ultra filter.

The separation of the sol particles from the liquid medium and electrolytes by filtration through an ultra filter is called as ultra filtration.

Ultra filtration is a slow process. Gas pressure (or suction) has to be applied to speed it up. The colloidal particles are left on the ultra filter is the form of slime. The slime may be stirred in to fresh medium to get back the pure sol. By using graded ultra filters, the technique o ultra filtration can be employed to separate sol particles of different sizes.



Properties of sols :-

A. **Colour** : The colour of a hydrophobic sol depends on the wave length of the light scattered by the dispersed particles. The wavelength of the scattered light again depends on the size and the nature of the particles. This is fully bore out from the following data

Colour of Ag solution Particle Diameter

Orange yellow Orange red Purple Violet 6 ×10⁻⁵mm 9 ×10⁻⁵mm 13 ×10⁻⁵mm 15 ×10⁻⁵mm

B. Optical properties of sols:

1. **Sols exhibit Tyndall effect** : When a strong beam of light is passed through a sol and viewed at right angles the path of

light shows up as a hazy beam or cone. This is due to fact that sol particles absorb light energy and that emit it in all directions in space. This scattering of light as it called, illuminates the path of the beam in the colloidal dispersion.

The phenomenon of the scattering of light by the sol particles is called Tyndall effect. The illuminated beam or cone formed by the scattering of light by the sol particles is often referred as Tyndall beam or Tyndall cone. True solutions do not show Tyndall effect.



· Jyndaueffect

- 2. Ultra microscope shows up the presence of individual particles:
 - Sol particles cannot be seen with a microscope Zsigmondy used the tyndall phenomenon to set up an apparatus named as the ultramicroscopic. Ultramicroscopic shows of the presence of ultra particles. Individual sol particles appear as bright sprects of light hence they do not show size and shape of sol particles including pigments viruses and bacteria can be known by using electron microscope

3. Sol Particles can be seen with an electron microscope

 It gives the picture of individual particles in the order of 10,000magnification. Thus size and shape of sol particles including pigments Viruses and bacteria can be grown known by using electron microscope.

C. Kinetic properties of sols :-

Brownian movement : When a sol is examined with an ultra microscope, the suspended particles are seen as shining specks light. By following an individual particle it is observed the particle is undergoing a constant rapid motion. It moves in a series of short straight lines paths in the medium, changing directions abruptly.

The continuous rapid zigzag movement executed by a colloidal particle in the dispersion medium is called Brownian movement or motion.

This phenomenon is so named after sir Robert Brown who discovered it in 1827. Suspensions and true solutions do not exhibit Brownian movement.



Brownian movement

D. Electrical properties :

1. The sol particles carry an electric charge : This important property carry both positive and negative charge make the sols stable. The natural forces of repulsion between similarly charged particles from aggregation this gives stability to sols.



2. **Electrophoresis:** It electric potential is applied across two platinum electrodes dipping in a hydrophilic sol the dispersed particle move toward one or the other electrode.

The movement of sol particles under an applied electric potential is called electrophoresis or cataphorosis.



3. **Electro osmosis**: The movement of the dispersion medium under the influence of applied potential is known as electro osmosis.

It is a direct consequence of existence of zeta potential between the sol particles and the medium.



E. Coagulation or Precipitation :

The flocculation and setting down of the discharge sol particles is called coagulation or precipitation of sol. The coagulation or precipitation of a given sol can be brought above in four ways

- 1. By addition of electrolytes
- 2. By electrophoresis
- 3. By mixing two oppositely charged sol
- 4. By boiling

1. By addition of Electrolytes :

When excess of an electrolyte is added to a sol, the dispersed particles are precipitated. The electrolyte furnish both positive and negative ions in the medium. The sol particle absorb the oppositely charged ions and get discharged. The electric neutral particles then aggregate and settle down as precipitate.

The precipitation power of an electrolyte or is experimentally determined by finding the minimum concentration mill moles per liter required to cause the precipitation of a sol in 2 hours. This is called the flocculation value. The smaller the flocculation value the higher the precipitation power of an ion.

2. By Electrophoresis :

In electrophoresis the charged sol particles migrate to the electrode of opposite sign. As they come in contact with the electrode, the particles are discharged and precipitated.

3. By mixing two oppositely charged sol:

The mutual coagulation of two sols of opposite charge can be effected by mixing them. The positive particles of one sol are attached by the negative particles of the second sol. This is followed by mutual adsorption and precipitation of both the sols. Examples :- Ferric hydroxide (+ve sol) &

Arsenious sulphide (-ve sol) forms such a pair

4. By boiling :-

Sols such as sulphur and silver halides dispersed in water, may be coagulated by boiling. Increased collisions between the sol particles and water molecules remove the adsorbed electrolyte. This takes away the charge from the particles which settle down.

F. Protective action of Sols :- Lyophobic Sols are readily precipitated by small amounts of electrolytes. However these sols are often stabilized by the addition of lyophilic sols.

The property of lyophilic sols to prevent the precipitation of a lyophobic sol is called protection.

The lyophilic sol used to project a lyophobic sol from precipitation is referred to as a Protective colloid.

Example : If a little gelatin (hydrophilic colloid0 is added to a gold sol (hydrophobic sol), the latter is protected. The protected gold sol is no longer precipitated on the addition of sodium chloride.

Gold Number :

The lyophilic colloids differ widely in their power of protection. The protective action of different colloids is measured in terms of Gold number introduced by Zsigmondy.

The gold number is defined as the number of milligrams of a hydrophilic colloid that will just prevent the precipitation of 10ml of gold sol on the addition of 1ml of 10 percent sodium chloride solution.

The onset of precipitation of the gold sol is indice by a colour change from red to blue when the particle size just increases.

The smaller the gold number of a hydrophilic colloid the greater is its protective power. Gelatin has a small gold number and is an effective protective colloid. Starch has very high value, which shows that it is an ineffective protective colloid.

Lyophilic colloid	Gold number
Gelatin	0.005 - 0.01
Egg albumen	0.08 - 0.10
Gum Arabic	0.10 - 0.15
Potato starch	25

Gold numbers of some hydrophilic colloids

The use of protective colloids to stabilize colloid systems is widespread. In the preparation of ice cream, gelatin is added to act as a protecting agent to the colloidal particles ice. If the ice particles coagulate, the smooth texture of ice cream is lost. Argyrol, used in eye drops, is a sol of silver protected by organic material.

Lecture No: 6

Gels – Types of Gels, Properties of Gels, Food Gels

Gels :-

A get is a jelly – like colloidal system in which a liquid is dispersed in a solid medium.

Example : when a warm of gelation is cooled, it sets to a semisolid mass which is a gel.

The process of gel formation is known as Gelation.

Types of Gels

Gels may be classified into two types

- a. Elastic gels
- b. Non-elastic gels
- a. **Elastic gels :** Elastic gels are those which possess the property of elasticity. They change their shape on applying force and return to original shape when the force is removed.

Elastic gels are obtained by cooling fairly concentrated lyophilic sols. The linkages between the molecules are due to electrical attraction and are not rigid.

Examples : Gelatin, starch and soaps are examples of substances which form elastic gels

b. Non-elastic gels :

Non elastic gels are those which are rigid. They are prepared by appropriate chemical action. Thus silica gel is produced by adding concentrated hydrochloric acid to sodium silicate solution of the correct concentration. The resulting molecules of silica acid polymerize to form silica gel. It has a network linked by covalent bonds which give a strong and rigid structure.

Properties of Gels :

- 1. Hydration :- A completely dehydrated elastic gel can be regenerated by the addition of water. But once a non elastic gel is freed from moisture addition of water will not bring about gelation.
- 2. Swelling :- Partially dehydrate elastic gels imbibe water when immersed in the solvent. This causes increase in the volume of the gel and the process is called swelling.
- Syneresis :- Many inorganic gels on standing undergo shrinkage which is accompanied by exudation of solvent. This process termed as syneresis.
- 4. Thixotropy :- Some gels are semisolid when at rest but revert to liquid sol on agitation. This reversible sol-gel transformal is referred to as Thixotrophy. Iron oxide and silver oxide gels exhibit this property. The modern thixotropic paints are also are example.

Food Gels :

The fairly theoretical points discussed are illustrate by some food gels.

Plastic gels :

If tag oil is cooled, fat crystal can form and these oil aggregate those is vanderwaal attraction between the crystals and no repulsion. The crystal form fractal gel. This results is a rigid and brittle network. These properties are characteristic of what is known as a "plastic fat".

Caseinate gels :

Milk contains casein micelle, proteinaceous aggregates of about 120mm overage diameter, each containing some 10^4 casein molecules. The micelles can be made to aggregate, by lowering the p^H to about 4.6 (or) by adding a proteolytic enzymes that removes the parts of k-casein molecules that product into the solvent. Thus, the gel is rather weak and deformable for acid casein gels this values are about 10 pa. The acid gel is thus shorter (more brittle)

Gelatin :

Gelatin is closed to an ideal entropic gel. The flexible molecular strands between cross links are long and this causes the gels to be very extensible. It is also predominantly elastic because cross links are fairly permanent. Despite the serve treatment of the collagen during preparation of gelatin. The molecules tend to form triple helices broadly speaking proline helices like those in collages.
Polysaccharides :

These chains are fairly stiff, appreciable bending can occur only if chain length exceeds about 10 monomers. Common saccharides, cross links of polysaccharides molecules can be any of following 3 types.

Type -1 : Single helices :

The helices, as found in amylase, arrange them like in microcrystalline regions and if the concentrate is sufficiently great gelatin will occur with amylopectin, similar is observed in behavior.

Type 2: Double helices :

These occur in, K – carragenon below a shortly fined temperature.

Type -3 : Egg box junction:

These occur with some charged polysaccharides such as alginate, when divalent cations are present.

Concentrated Gels :

Starch occurs, naturally in rigid granules, most between 5 and 100 um in diameter. They are insoluble in water. Part of the amylopection is present in micro-crystalline regions, which gives considerably rigid nature to the granules. If starch granules are heated in excess water the gets gelatinized. These involves swelling as H₂O taken is seven times their own weight. Melting of micro crystalline leached amylase forms a gel network is which the swollen granules are trapped.

Mixed Gels :

Some mixture of polysaccharides may show enhanced gelation at a lower concentration. For instance, dilute xanthan or locust bean gum solutions do into show any of the yield stress.

Lecture No: 7

Emulsions Types of Emulsions, Preparation and properties of emulsions.

Emulsions : These are liquid – liquid colloidal systems. In other words an emulsion may be defined as a dispersion of finely divided liquid droplets in another liquid.

Generally one of the two liquids is water and the other, which is immiscible with water, is designated as oil. Either liquid can constitute the dispersed phase.

Types of emulsions :

There are two types of emulsions a. Oil-in-water type (o/w type) :



Examples of emulsions :

- 1. Milk is an emulsion of o/w type. Tiny droplets o liquid fat are dispersed in water.
- 2. Stiff greases are emulsions of w/o type, water being dispersed in lubricating oil.

Preparation of emulsions:

The dispersal of a liquid in the form of an emulsion is called emulsification. This can be done by agitating a small portion of one liquid with the bulk the other. It is better accomplished by passing a mixture of liquids through a colloidal mull known as homogenizer.

The emulsions obtained simply by shaking the two liquids are unstable. The droplets of the dispersed phase coalesce and form a separate layer. To have a stable emulsion small amount of a third substance called the emulsifier or emulsifying agent is added during the preparation. This is usual a soap, synthetic detergent, or a hydrophilic colloid.

Role of emulsifier :

The emulsifier concentrates at the interface and reduces surface tension on the side of one liquid which rolls droplets. Soap, for example, is made of a long hydrocarbon (oil soluble) with a polar head – COO-Na+ (water soluble). In oil in water type emulsion the tail is pegged into the oil droplet, while the head extends into water. Thus the soap acts as go between and the emulsified droplets are not allowed to coalesce.

Properties of Emulsifier :

Properties of Emulsifier :

1. De emulsification :

Emulsions can be broken or demulsified to get constituent liquids by heating, freezing, centrifuging or by addition of appreciable amounts of electrolytes. They are also broken by destroying the emulsifying agent.

For example : an oil water emulsion stabilized by soap is broken by addition of strong acid. The acid converts soap into insoluble free fatty acids.

2. Dilution :

Emulsions can be diluted with any amount of the dispersion medium. On the other hand the dispersed liquid when with it will at once form a separate layer. This property of emulsions is used to detect the type of emulsion.

Lecture No: 8

Foam – Formation and structure

Foam

Foams are much like oil in water type emulsions; but are dispersions of a hydrophobic fluid in a hydrophilic liquid.

Foam formation and structure :

To make a foam, a surfactant is needed. Almost any type will do, since the only criterion for its functional is that a certain gradient to be created. This does not that any surfactant is suitable to make a stable foam A fairly low concentration of surfactant suffices.

For most surfactants, Ostwald ripening will be substantial even during foam formation, implying that very small bubbles soon disappear and the bubble size distribution will become fair narrow. The buoyancy force soon is sufficient to cause mutual deformation of bubbles, causing the formation of flat lamellae between them. The stress due to buoyancy is roughly equal to Pwater g^H , where H is the height in the foam layer, about 100 pa for H = 1cm.

However, there is a marked stress concentration as spherical bubbles come into contact, and this means that bubbles a laplace pressure of 10^3 pa would become significantly flattened further drainage of interstial liquid causes the bubbles to attain a polyhedral shape. Where three lamellae meet, a prism shaped water volume, bounded by cylindrical surfaces, is formed. This structural element is called a plateau border. Residual small bubbles usually disappear by ostwald ripening. In this way, a fairly regular polyhedral foam is formed, not unlike a honey comb structure. In the lower part of a foam layer, bubbles remains more or less spherical.



A polyhedral foam itself may be considered a gel. Deformation of the foam causes an increase in curvature of bubbles, a corresponding increase in laplace pressure, and elastic behavior at small deformation. Then at greater stress, bubbles slip past each other and viscoelastic deformation occurs. There is thus a yield stress, which is readily observed, since even fairly large portions of foam retain shape under their own weight. This yield stress usually exceeds 100pa.

Lecture No: 9

Changes of carbohydrates on cooking – changes in pectin substances, changes in starch granules, changes in cellulose solubility, Hydrolysis of starch.

Changes of carbohydrates on cooking :

The changes that occur on cooking of to carbohydrates are

Changes in pectin substances :-

The determination of the amount of pectin substances in the raw vegetables, vegetables steamed 20 min and vegetables steamed 45 minutes and found that while there is a steady increase in the amounts of pectins and pectates as steaming process, there is a decrease in protopectin as well as total pectin substances. When

sections of tissue imbedded in paraffin and stained to show the middle lamella vegetables steamed 45 min had a much thinner middle lamella than the fresh tissue.

Changes in Cellulose :

The cellulose in cell walls undergoes some changes during cooking or other food processing methods. The resistance the cellulose from such well-known sources as cotton fibres, to action of hot water, has thrown doubt on the possibility of hydrolysis. On steaming, the cell wall thin out; this indicate a change in cellulose.

Lecture No: 10

Reaction involved in food processing

Changes in starch granules :

Although starch granules occurs in most plant tissues in storage leucoplasts surrounded by thin strands of cytoplasm, starch also occurs in the chloroplasts of leaf cells when light falls on the leaf. Chloroplast starch is taught to be only transient, i.e rapidly hydrolyzed, carried in solution to the storage cells and then resynthesized into the storage starch. During heating the starch granules swell if sufficient water is present. Tissue slices of steamed or boiled potatoes show swollen and often gelatinized starch granules. Occasionally when the cell is stained with iodine, the outline of starch granule can be seen, but more often the whole cell is filled with the gelatinized starch. Sometimes the cell ruptures and the gelatinized starch streams out.

Solubility :

In some cookery processes soluble carbohydrates are dissolved. This physical change is usually of importance in mixtures when sucrose is one of the components.

Hydrolysis of starch :

Hydrolysis of starches also occurs to limited extent during cooking. Occasionally the extent of hydrolysis may be so great that the thickening power of starch is decreased. Thus when lemon or cherry pie filling is thickened, the mixture must not be cooked too long after the starch is added or the viscosity decreases again. Dextrinisation of starch occurs on the crust of bread during baking but this is not simple hydrolysis. The starch molecule is degraded and the reactions which occur are much more complicated than hydrolysis.

Lecture No: 11

Starch – Starch granules, Granule gelatinization (Gelatinization of starch), crude fibre.

Starch :

Starch's unique chemical and physical characteristics and nutritional quality set it apart from all other carbohydrates. Starch is the predominant food reserve substance in plants and provides 70-80% of the calories consumed by humans world wide. Starch is unique among carbohydrates because it occurs naturally as discrete particles.

A second uniqueness is the most of the starch granules are composed of mixture of two polymers

- 1. An essentially linear polysaccharide called amylase.
- 2. A highly branched polysaccharide called amylopectin.

Starch Granules :

Starch Granules are made up of amylase and 1 or amylopectin molecules arranged radially. The clustered branches of amylopectin occurs as packed double helices.

Wheat starch granules are lenticular and have a bimodal or trimodal size distribution. Many of the granules in tuber and root starches. Such as potato and tapioca starches, tend to be larger than those of seed starches and are generally less dense and easier to cook. Potato starch granules may be as large as 100 um along the major axis. Only cereal starches contain endogenous lipids in the granules. These internal lipids are primarily FFA and lysophospholipod (LPC), largely lysophosphatidyl choline, with the ratio of FFA to LPL varying from one cereal starch to another.

Gelatinization of starch :

Starch when suspended in cooled H_2O can penetrate amorphous regions of starch without disturbing the micelle. If the mixture is heated the intra molecular H_2 bonding, is broken, then grains absorb more H_2O and swell. The swelling causes by refrigerance. The temperature at which the granules begin to swell rapidly and lose by refrigerant is called gelatinization temperature.



As the temperature of the starch increases in suspension above the gelatinization range the granules continuously swell, this increases the viscosity in swollen the granular when a starch thicken mixture is allow to cool.



Amylase can form stranges & flexible films which H_2O soluble & edible. Presence of amylopectin decrease the intramolecular binding & prevent the formation of film. This can be overcome by using high amylo-starch foods.

The gelatinization temperature is increased by poly hydroxy such as glycerol, sugar and gelatinization temperature decreased by salts such as NaCl, CaCl. The tendency towards retrogradation is enhanced at low temperature especially O^0C .

Crude Fibre :

The sum of all those organic compounds of the plant cell membrane and supporting structures which in chemical analysis of plants food stuffs remain after removal of crude protein, crude fat, and nitrogen free extractives. Thus the crude fibre should be composed of the cellulose, hemicelluloses & some of the materials that encrust the cell walls such as lignin's and pectin substances.

Crude fat is removed by either extraction while crude protein is dissolved by hydrolyzing with dilute acid. During this hydrolysis, other compounds will likewise be hydrolyzed. Crude fibre values for a given food show the same variation with climate, soil conditions and conditions and degree of maturity as do other values.

The crude fibre is determined by drying to constant weight, weighing and then ashing and weighing again. The difference between the two weights is the crude fibre.

Interest in crude fiber determinations centres either in the detection of adulteration or from the nutritional standpoint in the bulkiness of the diet. Some foods are occasional adulterated with inert material by unscrupulous sellers.

The compounds in crude fiber make up most of the bulk or residue of the diet, and are not hydrolyzed by the digestive fluids of human beings. However, bacteria present in the colon of human beings may bring about considerable hydrolysis. The fibres that escape hydrolysis are excreted by faces. They serve a very real function here, however, because most of them are capable of absorbing water, and they render the faces soft enough to pass out of the body readily and bulky enough to induce defecation.

Lecture No: 12

Browning Reactions – Enzymatic browning and Non Enzymatic browning.

Browning

The formation of brown colour on the cut surface of the food is called browning.

Enzymatic Browning :

In enzymatic browning, polyphenols are oxidized by polyphenolses. Generally Tyrosine is oxidized by the polyphenolase enzyme.



Phenolic substrate tyrosine is the major for phenolase active in foods. Others are caffic acid, chlorogenic

Preventive measures in Enzymatic browning:

The methods commonly used for prevention of enzymatic browning are

- 1. Thermal inactivation of polyhenol oxidase (PPO)
- 2. Elimination of O_2 from the system
- 3. Change of P^{H} to prevent enzyme action

The optimal P^{H} of polyphenolase between 6 to 7 lowering of the P^{H} to 4 by the addition of citric acid inhabits the phenolase activity. Use of antioxidants like Ascorbic acid & Mode of action of polyphenolase.

Polyphenolase contains copper as a prosthetic group. The optimum p^H for the activity is between 5 to 7. The enzyme catalysis two types of reactions described below.

1. Oxidation of monophenol to orthodiphenol : Tyrosine is oxidized first to dihydroxy phenyl alanine (DOPA).

(0)

Tyrosine \rightarrow 2,3 – Dihydroxy phenyl Alanine

 Oxidation of orthodiphenol compounds to Quinones.
 Polyphenolase oxidase to some orthophenol compounds to some corresponding phenols.

DOPA _____ Orthoquinone.

3. Finally a brown colour pigment or complex polymer of polyphenols is from

Orthoquinone — Melanin's

Non Enzymatic browning :

The formation of brown discolouration in foods during heat processing and storage has been observed for a long time. This non enzymatic browning is described by Maillard Hence called as Maillard reactions (in 1912). He reported that brown condensation products are formed when a mixture of reducing sugar and amino acids is heated. This reaction is called Maillard reaction a major cause of browning.

As result of studies by many workers 4 distinct mechanism are involved is non enzymatic browning is foods.

- 1. Maillard reactions involved in interaction between reducing sugars, amino acids & proteins.
- 2. Reaction of oxidative products of ascorbic acid with protein and Amino acids.
- 3. Reaction of oxidative products of PUFA with A.A's and proteins.
- 4. Caramalization of sugar Services of reactions that begin with a carbonyl group (eg: sugar) & amino group (Eg: protein).

Beneficial:

Discolourization of milk when cooking

Preventive measures of non-enzymatic browning:

The browning reactions can be prevented or retarded by the following reactions

- 1. Storing the material low temperature i.e to 5° c.
- 2. Keeping the moisture content of dry fruits products below 4%
- 3. Excluding O_2 in the case of products containing Ascorbic acid & fat to prevent their oxidation.
- 4. Addition of sulphur dioxide or bisulphites in concentration of dehydrated vegetables.





Lecture No: 13

Functional Properties of Sugars :

Learning Objectives:

- To understand to 3 main groups of carbohydrates Mono, di and polysaccharides.
- To identify the different CHO's in foods i.e sugar, starch and fibre.
- To recognize the functional properties of CHO's in food.

Functions:

- CHO's cover a wide range of natural compounds such as starches & sugars which are all based on monosaccharides.
- All CHO's are compounds of the chemical carbon, hydrogen & D₂ & have the general formula (CH₂O)_n
 Eg: Glucose (CH₂O)₆ = C₆ H₁₂ O₆

Physical properties :

- a. Solubility
- b. Freezing point
- c. Boiling point

Microbial Properties:

- a. Preservation
- b. Fermentation

Chemical Properties :

a. Antioxidant property

Sensory properties :

- a. Sweetness
- b. Texture
- c. Appearance.

Physical properties.

- 1. **Solubility** : All monosaccharides and disaccharides are soluble in distilled H_2O Polysaccharides are soluble in hot water.
- 2. Freezing Point: Sugars is effective in lower freezing point. F.P depression is an important property in preparation of ice creams & freeze dry foods. To ensure the development of final crystal structure product smoothness.
- 3. **Boiling point:** The concentration of sugar in a solution effects the boiling point by raising it. This characteristic property is important in candy preparation. Boiling point elevation allows for more sugars to be dissolved in solution. Creating a super saturate and more concentrated solution. It is the specific concentration of the supersaturated sugar syrup which is achieved at specific boiling point.

Microbial Properties:

1. Preservation:

Sugars play a role in a preservation of many food products. The addition of sugar to jams and jellies inhabit the microbial growth and subsequent spoilage. Having ability to absorb water sugar with draws the moisture from microorganisms. As a result microorganisms become dehydrated & cannot multiply & cannot cause a food spoilage. Interaction between sugar and water controls the level of moisture in banked products. Sugar has high effinity for H₂o helps to slow the moisture less in cakes & biscuits.

2. Fermentation :

Sugar is extremely important in the baking & brewing industries. Yeast use sugar as a food to produce ethanol, $Co_2 \& H_2O$ through the process of fermentation. In baking sugar increase the effectiveness of yeast by providing an immediate & more utilizable source of nourishment for its growth. Fermentation of sugar by yeast also occurs in the production of wine & beer. Sugar or other CHO's are the raw materials for the production of alcohol. The extent through which fermentation reaction is allowed to proceed contributes to the alcohol content and sweetness of the wine and also flavor of beer.

Chemical properties :

1. Antioxidant properties :

Sucrose has been reported to exhibit antioxidant properties which helps in prevent the deterioration of texture and flavours in canned foods & vegetables. These effects may be partially attributed to sucrose, ability to lower A_w in addition the products of the hydrolysis of sucrose appear to have the ability to block the size of the ions such as copper & ion to a lesser extent cobalt. This characteristic property of monosaccharide helps in food preservation by retarding the catalytic oxidative reactions.

Sensory Properties :

1. Sweetness:

Sweetness is the most recognized functional property of sweetness. Sweetness is also associated with feelings of

pleasure which contribute to the appearance of sweet foods. The combination of sugar and fats in confectionaries provide a sweet taste and texture that compliment each other. In beverages such provides sweetness without altering the flavours of beverages

2. Texture :

Sugars makes an important contribution to the whey. We perceive the texture of foods commonly refers to as mouth feel. For eg: Glucose syrups in ice creams provide a body and texture perceived as smoothness. Adding sugar syrup helps to prevent lactose crystallization. Sugars also act to tenderize bakery products by slowing the rate at which starch molecules become interlinked & protein breakdown. Glucose, fructose, sucrose, maltose are used in bread making to increase dough yield & prevent excessive stickiness.

3. Appearance :

The reactivity of glucose on heating contribute to orange red colour in bread i.e result of sugar in non-enzymatic browning. Caramelization of fructose produces a dark brown colour. Bread that contain sucrose often yield a dark brown color.

Carbohydrates in foods :

Many foods contain some CHO's but the amount of sugar, starch and fibre differ. Sugar are naturally present in foods such as milk, fruits, vegetables & honey. In the UK, sugar beet & sugar cane are the most common sources of sugar. Honey, treacle & golden syrup are also popular. Starch is present in foods such as potatoes, bread rice and pasta. Fibre is present in whole grains, fruits & vegetables especially the skin covering of seeds.

It is a mixture of substances (mainly complex CHO's) which cannot be digested in the small intestine.

Fibre also known in UK as non starch polysaccharide (NSP) eg: Cellulose & pectin & Guar gum is found in fruits, vegetables, beans & cereals.

Carbohydrates and its functional properties in food products:

Carbohydrates perform different functions in food products. They are

- 1. Help to cause the color change of bread, toasts & bakery products
- 2. Contribute to the chewiness, color & sweet flavor of caramel.
- 3. Thicken products such as sauces & custards.

Dextrinization :

Foods which are baked grilled or roasted undergo color, odor & flavor changes. This is due to a reaction involving protein & a reducing sugar. These polymerize to form complex brown colored compounds called dextrins. The compounds contribute to the colour & flavor of many foods such as toasts, bread & croissants. This is known as non-enzymatic browning (Maillard reaction)

Parts of Amino acids and sugar molecules in foods combine, when heated to form brown colour compounds which changes its colour, odour & flavor

Caramelization:

When sucrose (sugar) is heated above its M.P (90⁰C) it undergoes a physical change to produce a caramel.

This happens more readily without H_2O , however syrups will caramelize with rapid heating.

This process is used extensively in the production of confectionary. Overheating will cause the substance to become bitter & dark.

Lecture No: 14

Pure proteins of plants and animal origin with their functional characteristics.

Proteins of plant origin :

1. Vegetable proteins:

Fresh vegetables are not considered to be very good source of proteins . On fresh weight basis the protein content of some common vegetables are carrot and let -1%, white potatoes, asparagus and green beans -2% and fresh peas -6%.

Although protein content of potatoes is only 2% quality is considered to be good to excellent due to relatively high content of the amino acids – lysine and tryptophan. Outer layers the so called "cortex" of tubers contain most of the proteins. These layers also have a much higher content of essential amino acids, than do the inner layers. The outer layer proteins can be increased by selective plant breading.

2. Cereal proteins:

Cereal grains, properly ripened and dried optimum storage stability, have protein content ranging from proteins are found in various morphological tissues of difference grains. Much of the endosperm storage proteins in kernel of several cereal proteins are located in the sub-cellular granules or organelles known as protein bodies.

3. Seed proteins :

Although a large number of plants produce seed having protein content in excess of 15%, only a few are utilize for food. Proteins comprise a significant portion of food reserves which is so important during germination. Proteins of most seeds are globulins. Which are soluble in water or dilute salt solutions.

4. Nuts :

Nuts are excellent sources of proteins. Examples of nuts include cashew nuts, almond nuts, hazel nuts, coconuts, walnuts, brazil nuts, pistachio nuts etc.., some nuts like almonds contains complete proteins. Those nuts that do not contain complete proteins can be extremely useful sources of proteins if they are eaten in combination with other protein foods, 01 with milk or cheese or with vegetables.

Proteins of Animal Origin:

1. Meat :

Skeletal or striated muscles are used for food purposes. Flesh of cattle, sheep and swine comprise most of meat contents. Edible meat from these is designated as Red meat a term descriptive of colours of beef, lamb or pork, as opposed to light and dark colors of poultry meat. The red colour is primarily due to myoglobin.

2. Milk:

A value of 3.5% protein is often considered as an overage for milk. Milk protein has traditionally been divided into 2 classes.

1. Casien

2. Whey protein

Casien is a heterogeneous group of phosphor protein, which can be precipitated from raw skimmed milk by acidification. Whey fraction mainly consists of β -lacta albumin, α – lacta albumin, immune globulins, bovine serum albumin etc..

3. Eggs :

Roughly, the chicken egg consists of 11% shell, 31% yolk & white. Yolk appears to be the initial source of food, while egg in seems to act as a protective barrier. The white and yolk differ their composition.

- Yolk : Yolk contains about 50% solids of which 2/3rd are lipi and proteins. On wet weight basis, egg yolk contains 31% fa of which 1.3% is cholesterol.
- White : Essentially an aqueous solution containing about 12% proteins.

4. Fish :

The edible portion is skeletal muscles of the body. Ever though the skeletal muscles of different animals are basically similar. Fish species used for food are fat more numerous & diverse than the mammalian species. This contains a high content of hemoprotein, which following the harvest, may catalyze oxidation of lipids and cause pronounced rancidity.

5. Shellfish :

Information on shellfish is fragmentary and incomplete. In shellfish the shell comprises of a large portion of live weight the fish and thus their edible content is low.

Lecture No: 15

Plant proteins – Cereal proteins, Tuber proteins & Pulse storage proteins.

Cereal Proteins:

In 1907 Osborne separated wheat proteins based on their solubility. They are divided into 4 types.

- 1. Albumins
- 2. Globulins
- 3. Prolamines
- 4. Glutelins

Prolamines and Glutelins are the storage proteins. Albumins are water soluble. Globulins are the salt soluble in proteins. Prolamines are soluble is 70% ethanol. Glutelins are insoluble.

In wheat the protein content is 12%. Cereal proteins are rich in sulphur containing amino acids such as methionine, cysteine and poor in lysine and threonine. Pulses are rich in lysine and poor in methionine. Pulses contain haemoglutenins and lectins which are anti nutritional factors.

Apple — 4 – methyl –L- Proline

Peanut ____ 4-methylene glutamic acid

Banana --- Dopamine

Red beet \rightarrow Isobutanidin glycon

In wheat prolamines are responsible for dough viscosity and glutenins for dough strength and elasticity.

Tuber Proteins:

Approximately 70 – 80% of the extractable proteins is potato tuber are classified as storage proteins. Up to 40 individual proteins have been separated from potatoes by electrophoresis. The heterogeneity of these storage proteins appear to be due to charge differences, and it is likely that this is a reflection of different amounts of amide in the polypeptide chain. Protein patters obtain by iso electric focusing on poly acryl amide gel can also be used to differentiate potato cultivars.

Pulse Storage Proteins :

Legume Seeds are characterized by a relatively high content (20-40%) of protein. The limiting essential amino acids in legumes are methionine and cysteine. Soyabean proteins do contain prolamines and glutelins, although peanuts, peas and broad beans contains 10 – 15% glutelins – Pulses also contain protein and glycoproteins called haemoaglutinins or lectins. Certain glycansites on erythrocytes bind to lectins causing agglutination or precipitation of cells. The solubility and food related functional properties of soyabean proteins can be improved by limited hydrolysis with proteolylic enzymes, such as trypsin. Excessive hydrolysis of soyabean proteins is normally undesirable because to go rise to bitter-tasting peptides.

Lecture No: 16

Milk proteins - casein, whey proteins & colostrums

Milk contains all the nutrients necessary to sustain life. Milk is a white or yellow white opaque. The colour is influenced by scattering & adsorption of 18 by milk fat globules & protein miscell's. Milk fat occurs in the form of droplet or globules surrounded by a membrane and emulsified in milk serum (whey). The fat globules (whey) separate after prolong storage or after centrifugation. Proteins of various sizes are dispersed in milk serum. They are called miscalls and consists ca salts of casein molecules various proteins, Carbo hydrates, minerals and other ingredients are solublized in milk serum.

The specific density of cows milk ranges from 1.029 to 1.039 at 15° C. Defatted (skim) milk has a higher specific density than cold milk.

In 1877, O.Hamersten distinguished 3 proteins in milk. They are

- 1. Casein
- 2. Lactoglobulin
- 3. Lactoalbumin

Casein is the main portion & major constituents of whey proteins or β – lactoglobulin A&B and α -lactoalbumin. Other protein constituents are casein. Casein are not denaturable because of the lacking of tertiary structure.

There are different variance of casein lines α – S, casein, α - S₂ casein, α casein, β - casein. In whey protein major components are β -lactoglobulin & α -lactalbumin, seromalbumin, immunoglobules, IgG₁; IgG₂, & protease peptone.

Whey protein :

B-lactoglobulin consists of a monomeric unit with moleculac weight of 18k tones & consists of 162 aminodis β – lactoalbumin has 56 system residues.

α – Lactalbumin:

It has 8 systems residues and its amino acids sequence similar to that of lysozyme.

Colostrums:

Colostrum is the first secretion of the mammary gland on parturition and differs markedly from milk in its protein composition. During the first few days after the birth of the calf, the composition of lacteal secretion gradually changes until that characteristic of milk appears. The most striking difference is in the globulin fraction that carries the antibodies which gives protection against certain diseases colostrums does not appear to be so essential in the feeding of human infants, since antibodies are more readily transferred by way of the placenta.

Lecture No – 17

Egg proteins – Egg white proteins, Egg yolk proteins

Egg proteins :

Eggs are nearly perfect protein foods and have other high quality nutrients, they are readily digestible and can provide a significant portion of nutrient required daily for growth maintenance of body tissue. They are utilized in many ways in both for industry an home. Main portion of egg are egg yolk, egg white (albumin)

Egg white (Albumin)

It is a 10% of sol of various proteins. The most important albumin proteins are ovalbumin, conalbumin, ovamucoid which acts as a protein inhibitor, ovamucin, lysozyme (ovaglobulin G_1). It is a N – acetyl muraminase ovaglobulin. G_2 , ovalglobulin G_3 , which are good foam builders. Flavo proteins which binds riboflavin, ovaglycoprotein, ova macroglobulins ova inhibitors which acts as a protein inhibitors. The major protein of the egg white is ovalbumin present around is 54%.

Ovalbumin :

It is the main albumin protein, other constituents present in egg white or lipids, CHO's, vitamins and minerals.

Egg yolk proteins:

Yolk is a fat in water in emulsion without one thirds of protein and $2/3^{rds}$ of lipids. Yolk contain particles of different sizes that can be classified into two

- 1. Yolk droplets
- 2. Granules

Yolk droplets :

They have diameter range from 20-40um. They resemble fat droplets mostly contain lipids. Some have protein membranes. They are a mixture of lypo proteins with a low density.(LOL).

Granules:

They have a diameter ranging from 1 to 1.3mm. They are smaller than yolk droplets. They have a sub structures and consists of proteins.

Lecture No: 18 & 19

Lipids – Introduction – Fatty Acids, Acyglycerol, phospholipids, classification – Milk fats, Lauric acid, Animal fats, Marine Oils, vegetable butters, oleic – linoleic acids & linolenic acids.

Introduction :

Lipid consists of a broad group of compounds that are generally soluble in organic solvents but sparingly soluble in water. They are major components of adipose tissue and together with proteins and carbohydrates they constitute the principal structural components of all living cells.

Food lipids are consumed either as

- 1. Visible fats : Butter, lard and shortening
- 2. As constituents of basic foods : Milk, cheese and meat

Lipids in food exhibit unique physical and chemical properties. Their composition, crystalline structure, melting properties and ability to associate with water are important to their functional properties in many foods. During processing, storage and handling of foods, lipids undergo complex chemical changes and react with other food constituents, producing numerous compounds both desirable and deleterious to food quality

Dietary lipids play an important role in nutrition. They supply calories, EFA, acts as vitamin carriers and increase the palatability of food.

Fatty acids:

Saturated fatty acids

Unsaturated fatty acids

Classification:

Edible fats are traditionally classified into the following groups.

1. Milk fats :

Fat of this group are derived from the milk of ruminant particular dairy cows. Although the major fatty acids of milk fat are palmitic, oleic and stearic, this fat is unique among animal fats in that it contains appreciable amounts of the shorter chain acids C_4 to C_{12} , small amounts of branched and odd-numbered acids and trans-double bonds.

2. Lauric acids :

Fats of this group are derived from certain species of palm, such as coconut. The fats are characterized to their high content of lauric acid (40-50%) moderate amounts of C_6 , C_8 and C_{10} fatty acids, low content of unsaturated acids and low melting points.

3. Vegetable Butters :

Fats of this group are derived from the seeds of various tropical trees and are distinguished by their narrow melting range

which is due to mainly to the arrangement of fatty acids in the tri acyl glycerol molecules.

4. Oleic –linoleic Acid:

Fats in this group are the most abundant. The oils are of vegetable origin and contain large amounts of oleic and linoleic acids, and less than 20% saturated fatty acids. The most important members of this group are cottonseed, corn, peanut, sunflower, safflower, olive, palm and sesame oils.

5. Linolenic Acids:

Fats in this group contain substantial amounts of linolenic acid. Examples of soyabean, rapeseed and flax seed, wheat germ, hempseed and perilla oils, with soyabean being the most important. The abundance of linolenic acid in soyabean oil is responsible for the development of an off –flavour problem known as flavor reversion.

6. Animal fats:

This group consists of depot fats from domestic land animals, all containing large amounts of C_{16} and C_{18} fatty acids, medium amounts of unsaturated acid, mostly oleic and linoleic and small amounts of odd-numbered acids.

7. Marine Oils

These oils typically contain large amounts of long chain omega-3-polyunsatured fatty acids, with up to six double bonds, and they are usually rich in vitamins A and D. Because of their high degree of unsaturation, they are less resistant to oxidation than other animal or vegetable oils.

Acylglycerols :

Neutral fats are mono, di and trimesters of glycerol with fatty acids, and are termed mono acyl glycerols, di acyl glycerols and tri acyl glycerols, respectively. Use of the old terms mono, di and triglycerides is discouraged . The compound shown here can be named any of the following tristearoylglycerol, glycerol tristearate, stristearin.

Phospholipids :

The term "phospholipid" may be used for any lipid containing phosphoric acid as a mono or diester. "Glycerophospholipid" signifies any derivative of glycerophosphoric acid. Thus all phosphoglycerols contains polar head and two hydrocarbon tail.

$$CH_{2}OOC(CH_{2})_{16}CH_{3}$$

$$| CH_{3}(CH_{2})_{4}CH = CHCH_{2}CH = CH(CH_{2})_{7}COOCH$$

$$| O$$

$$CH_{2}O - P - O (CH_{2})_{2} NCH_{3}$$

$$| O$$

Lecture – 20

Physical aspects of lipids – crystallization & consistency Crystallization :

Formation of a solid from a solution is a complicated process in which molecules is coming in contact and they in contact and they interact to form highly ordered structures known as "nuclei". This process is known as nucleation. Nucleation can be encouraged by stirring the super cooled liquid. Following nucleation enlargement of the nuclei known as crystal growth progress at a rate dependant mainly on the temperature. In the crystalline stage atoms or molecules arranged to form a repeatable highly ordered 3dimensional pattern. This 3-dimensional arrangement in space known as "space lattice". Fatty acids tend to form double molecules oriented head to tail, head to head by sharing hydrogen bond between carbonyl groups.



Consistency:

All saturated Fatty acids are solids at room temperature and all unsaturated fatty acids are liquids at room temperature.

Lecture No: 21

Chemical aspects of lipids – lipolysis, Autoxidation, Thermal decomposition.

1. Lipolysis :

Hydrolysis of ester bonds in lipids is termed as lipolysis. This can be occur by

- a. Enzyme action or
- b. Heat and moisture resulting in the liberation of FFA.

Free fatty acids are absent in fat of living animal tissue. They can form, by enzyme action after the animal is killed. Since edible animal fats are not usually refined, prompt rendering is of particular importance. The temperatures commonly used in the rendering process are capable of inactivating the enzymes responsible for hydrolysis.

The release of short chain fatty acids by hydrolysis is responsible for the development of an undesirable rancid flavor in raw milk (Hydrolytic rancidity). On the other hand certain typical cheese flavours are produced by deliberate addition of microbial and mild lipases. Controlled and selective lipolysis us used in manufacture of yogurt and bread.

Neutralization with alkali is required for most vegetables oils after they are extracted to neutralize the released FFA on hydrolysis. Lipolysis occurs majorly during deep-fat frying due to large amounts of water released from food and the relatively high temperature used. Higher amounts of FFA released during frying causes decrease in surface tension of the oil and the reduction is quality of fried food. FFA released during frying are more susceptible to oxidation than are fatty acids esterifies to glycerol.

Phospholipid hydrolysis in most species of fish during frozen storage is associated with deterioration in quality. Hydrolysis of TAG's lead to increased lipid oxidation

Enzymatic lipolysis is used as an analytical tool in lipid research. Eg: Pancreatic lipase and snake venom phosplipase are used to determine the positional distribution of fattyacids in acylglycerol molecules.

2. Auto oxidation :

Lipid Oxidation is one of the major causes of food spoilage. This leads to development of off flavours and odors in edible oils and fat containing foods generally called oxidative rancidity. This oxidative rancidity render these foods less acceptable oxidative reactions can decrease the nutritional quality of food & certain oxidation products are potentially toxic.

Limited degree of lipid oxidation is desirable in aged cheeses and some fried foods. Auto oxidation, the reaction with molecular oxygen via a self catalytic mechanism is the main reaction involved in oxidative deterioration of lipids.

In foods lipids can be oxidized by both enzymatic and nonenzymatic mechanisms.

Fundamental steps of Auto oxidation :

Oxidation proceeds by sequential free radical chain reaction mechanism. Oxidation process is essentially a radical induced chain reaction. The reaction is divided into following steps

- Initiation
- Propagation
- Branching & Termination

Auto oxidation of fats proceed via typical free radical mechanisms characterized by

- 1. Catalytic effects of light and free radical producing substances
- 2. High yield of hydro peroxide.

The reaction $RH + O_2$ free radicals is thermodynamically difficult. Production of first few radicals i.e initiation step necessary to start the propagation reaction must be catalysed. Initiation of oxidation occurs by

- 1. Hydro peroxide decomposition or
- 2. By metal catalysis or
- 3. By exposure to light

After initiation, oxidation is propagated by abstraction of hydrogen atoms at positions alpha to fatty acid double bonds producing free radical species Radical oxygen addition that occurs at these locations results in the production of peroxy radicals.

Enzyme catalyzed lipid oxidation:

Sequential enzyme action starts with lipolysis. Released PUFA are oxidized by either lipoxygenase or cyclo – oxygenase to form hydroperoxides or endoperoxides respectively.

Factors influencing rate of lipid oxidation in food :

1. Fatty acid composition :

The no position and geometry of double bonds affect the rate of oxidation.

Relative rates of oxidation for Arachidonic, linolenic, lenoleic and olic acids are approximately 40:20:10:1 respectively

Cis acids oxidize more readily than trans isomers

Conjugated double bonds are more reactive than nonconjugated
Auto oxidation of Saturated fatty acids is extremely slow at room temperature. At high temperature SFA undergo oxidation at significant rates.

FFA Vs corresponding acyl glycerols:
 FFA oxidize at slightly low rate than when esterified to glycerol.

3. Oxygen concentration :

When oxygen is abundant the rate of oxidation is independent of oxygen concentration, but at very low oxygen concentration the rate is approximately proportional to O_2 concentration. In general, the rate of oxidation increases as the temperature is raised. The rate of oxidation increases in direct proportion to the surface area of the lipid exposed to air.

4. Moisture :

In model lipid systems and various fat containing food the rate of oxidation depends strongly on water activity. In dried foods with very low moisture contents, oxidation proceeds very rapidly. Increase the a_w to about 0.3 retards lipid oxidation and produces a minimum rate. This protective effect of small amounts, water is believed to occur by reducing the catalytic activity of metallic catalysts by quenching free radicals and by impeding access of oxygen to the lipid. At higher water activities ($a_w = 0.55 - 0.85$) the rate oxidation increases again as result of increased mobilization catalysts and oxygen.

5. Temperature

The rate of oxidation increased as the temperature increases. Temperature influences the relationship between rate and oxygen partial pressure. As temperature is increased changes is oxygen partial pressure. As temperature is increased changes in oxygen partial pressure have a smaller influence on rate because oxygen becomes less soluble in lipids and water as the temperature is raised.

6. Pro oxidants :

Transition metals particularly those possessing two or more valency states and a suitable oxidation –reduction potential between them leg : cobalt, copper, iron, manganese and nickel) are effective pro oxidants.

7. Radiant energy:

Visible, U.V and gamma radiation are effective promoters of oxidation.

8. Surface area:

The rate of oxidation increases in direct proportion to the surface area of the lipid exposed to air.

- 9. Physical state
- **10.** Molecular Orientation
- **11.** Emulsification
- 12. Molecular mobility & Glass transition
- **13.** Antioxidant

Thermal Decomposition:

Heating of food produces various chemical changes, some of which can be important to flavor, appearance, nutritive value and toxicity. Not only do the different nutrients in food undergo decomposition reactions, but these nutrients also interact among themselves n extremely complex ways to form a very large no of new compounds.

The chemistry of lipid oxidation at high temperature is complicated by the fact that both thermolytic and oxidative reactions are simultaneously involved. Both saturated & UFA undergo chemical decomposition when exposed to heat in the presence of O_2 . The compounds formed are cyclic and acyclic dimmers, long chair alkanes, aldehydes, ketones etc. A schematic summary of these mechanisms are



Lecture No: 23

Technology of edible fats and oils – Rendering, Pressing, Solvent extraction

Technology of edible fats and oils : Three principle methods are used for extraction of edible fats and oils from the animal or vegetable tissues in which they occur. They are

Rendering :

Rendering is a process by which fat is removed from a tissue by heat. It is called trying out. The tissue containing a high percentage of fat is carefully removed from the animal and chopped and minced. Heat allows the lipid to escape from the cells. If the heat is high the cells are completely ruptured, a cooked flavor develops and cracklings are left the oil floating on top. Rendering can carried out either in the presence of water as in wet rendering or in its absence as in dry Rendering

a. Wet Rendering:

In this process is the fat can be separate by gentle heat in a open kettle or in autoclave in the presence of steam. In the first method the well chopped tissue is introduced into an open kettle along with a charge of water, stirred gently and heated to about 50°C. The fat floats to the top and is carefully skimmed off. It has a blend flavor and requires little deodorization but the process does not remove all of the fat from the tissue. Now a day's autoclaves and steam in digesters at high temperature and pressures of 40 to 60 ps is used. In this way the tissue is quite well disintegrated and separation of fat is efficient

b. Dry Rendering :

In this process used in cooking bacon. The tissue is heated and the fat separates as the protein is denaturated and water is evaporated. Commercially the process is carried out under vacuum is steam jacketed cookers.

1. Pressing:

It is application of high pressures to the oil bearing tissue to squeeze out the fat. The oil is removed by pressure form an expeller or screw press. In some cases such as the pressing olives, virgin oil is the first pressing of the fruit and is partial blend in flavor. The fruit is then subjected to subsequent pressing to give other grades of oil.

2. Solvent extraction:

In this method the oil is removed from tissues which have relatively low percentage of oil. Some times a tissue is subjected to pressing and then the press cake with its low fat con is extracted with a solvent. The solvent must be removed from oil after extraction of oil. The method is quite efficient but is expensive because of the inevitable loss of the solvent through evaporation. Common solvents are petroleum ether, Benzene, chlorinated hydrocarbon and carbon disulfide. The residue obtained after pressing or extraction is high in protein and is valuable feed for cattle.

Lecture No: 24

Technology of fats and oils – Rendering Hydrogenation and inter esterification.

1. Refining:

The crude oils extracted from the tissue often contains materials that must be removed. They are

- 1. Cellular material derivatives like protein and CHO's
- 2. Free fatty acids and phospholipids
- 3. Pigments
- 4. Odour compounds such as aldehydes, ketones and essential oils
- 5. Glycerides with high melting point.

The first step in refining most oils and fats is the removal of cell debris. Free fatty acids are present in some crude oils in good amount. Thus palm oil usually has about 5% free fatty acids. These can be fairly completely removed by steam refining.

Steam refining:

This consists of blowing steam through not oil through vacuum. This processes is used for the deodorization of fats. Oil with free fatty acids contains usually first subjected to steam refining this is followed by alkali refining. Those with low fatty acid contain may similarly undergo alkali refining.

Alkali refining:

In alkali refining hot oil is treated with a solution of alkali usually sodium hydroxide. Sometimes with sodium carbonate and occasionally with sodium salt.

The free fatty acids react with alkali and forms soap which are dispensable in water. The process is called saponification. The oil is then mixed with hot water and passed through a centrifuge that discharge.

Bleaching:

Pigments are removed by adsorption on pullers earth, other days etc., some times through the addition of small amount of charcoal (activated). This process is called bleaching. The oil is heated to 220° – 240° F and then agitated and filtered until the color of filter oil is sufficiently light. Chemical agents like oxidizing or reducing agents are not used for bleaching of edible oils, but used for waxes.

Steam deodorization

By steam deodorization fats and oils have render, so blend that it is difficult to defect their origin by taste or swell. By applying low pressures and small quantities of steam is applied for deodorization. The fat is heated and steam is injected into the bottom of the vessel. The oils are rapidly deodorized at 425 to 475⁰F. If lower temperatures are used longer periods are required then it oil is rapidly cooled.

2. Hydrogenation :

Hydrogenation of fats involves the addition of hydrogen double bonds in the fatty acid chains. The process is of major important in the fats and oils industry. It accomplishes two major objectives. First it allows the conversion of liquid oils into semisolid or plastic fats mo suitable for specific applications, such as in shortenings and margarine second, it improves the oxidative stability of the oil.

In practice, the oil is first mixed with a suitable catalyst heated to a desired temperature (140-225°C), then exposed, while stirred to hydrogen at pressures up to 60 psig. Agitation is necessary to aid dissolving the hydrogen, to achieve uniform mixing of refined bleached, low in soap, and dry the hydrogen gas must be dry and tree of sulphur, CO₂ or ammonia and the catalyst must exhibit long term activity, function in the desired manner with respect to selectivity of hydrogenation and isomer formation and be easily removable by filtration. The course of reaction is usually hydrogenation monitored the bv determining the change in refractive index, which is related to the degree of saturation of the oil. When the desired end is reached, the hydrogenation oil is cooled and catalyst is removed by filtration.

3. Interesterification:

Interesterification is one of processes that can be applied to improve the consistency of such fats and to improve their usefulness. This process involves rearranging the fatty acids so they become disturbed randomly among triacylglycerol molecules of the fat.

Principle :

The term "interesterification" refers to exchange of acyl radicals between an ester and acid (acidolysis), or an ester and alcohol (alcoholysis) or an ester and ester (transesterification). It is the latter reaction that relevant to industrial inter esterification of fat, also known as randomization. It fat only contains two fatty acids A & B, 8 possible TAG species are possible according to rule of chance.



Regardless of the distribution of the two acids in the original fat (eg: AAA & BBB or ABB,ABA,BBA), interesterification results in the "shuffling" of fatty acids within a single molecule and among TAG molecules until an equilibrium is achieved in which all possible combinations are formed.

Lecture No: 25

Frying technology of fats and oils – chemistry of frying & behavior of the frying oil.

Chemistry of frying:

Foods fried in fat make significant contributions to the calories in the average U.S. diet. In the course of deep fat frying, food contacts oil at about 180°C and is partially exposed to air for various periods of time. Thus frying more than any other standard food process and handling method, has the great potential for causing chemical changes in fat, and sizeable amount of this fat are carried with food.

Behavior of the frying oil :

The following classes of compounds are produced from the oil during frying.

1. Volatiles :

During frying, oxidative reactions involving the formation and decomposition of hydro peroxides lead to such compounds as saturated and unsaturated aldehydes, ketones, hydrocarbons, lactones alcohols, acids and esters. After oil is heated for 30 min at 180[°]c in the presence of air, the primary volatile oxidation products can be detected by gas chromatography. Although the amounts of volatiles produced vary widely, depending on oil type, food type and the heat treatment, the generally reach plateau values, probably because a balance is achieved between formation of the volatiles and loss through evaporation or decomposition.

2. Non polymeric polar compounds of moderate volatility:

The compounds are produced according to the various oxidative pathways involving the alkoxy radicals.

3. Dimeric and polymeric acids, and dimeric and polymeric glyceride:

These compounds occur, as expected from thermal and oxidative combinations of free radicals. Polymerization results in a substantial increase in the viscosity of the frying oil.

4. Freefatty acids :

These compounds arise from hydrolysis of triacylglycerls n the presence of heat and water.

Lecture No: 26

Behavior of the foods during frying, chemical and physical changes, Tests for Assessing the quality of frying oils.

1. Behavior of the Foods During frying:

The following events occur during frying of food are:

Water is continuously released from the food into the hot oil. This produces a steam distillation effect, sweeping volatile oxidative products from the oil. The released moisture also agitates the oil and hastens hydrolysis. The blanket of steam formed above the surface of the oil tends to reduce the amount of oxygen available for oxidation.

Volatiles may develop in the food itself or from the interactions between the food and oil

Food absorbs varying amounts of oil during deep fat frying, resulting in the need for frequent or continuous addition of fresh oil. In continuous fryers, this result in rapid attainment of a steady state condition for oil properties.

The food itself can release some of its endogenous lipids into the frying fat and consequently the oxidative stability of the new mixture may be different from that of the original fat. The presence of food causes the oil to darken at an accelerate rate.

2. Chemical and physical changes:

The changes that occur in the oil and food during frying should not be automatically construed an undesirable or harmful. In fact some of these changes are necessary to provide the sensory qualities typical of fried food. On the other hand, extensive decomposition, resulting from lack of adequate control of the frying operation, can be potential source of damage not only to sensory quality of the fried food but also to nutritional value.

The chemical and physical changes in the frying fat are influenced by a number of frying parameters. Obviously, the compounds formed depend on the composition of both the oil and the food being fried. High temperature, long frying times, and mental contaminants favour volume ratios.

Tests for assessing the quality of frying oils:

Several of the methods for determining fat oxidation are commonly used to monitor thermal and oxidative decomposition of oils during the frying process. Measures of viscosity, FFA, sensory quality, smoke point, foaming, polymer formation and specific degradation products are also used with various degrees of success.

Because changes occurring during frying are numerous and variable, one test may be adequate for one set of conditions but totally unsatisfactory for another.

Petroleum ether Insoluble's:

It is suggested that a used frying fat be regarded on "deteriorated" if the petroleum ether insoluble's are 0.7% and the smoke point is less than 170° C, or if the petroleum ether insoluble's are 1.0% regardless of the smoke point. The method is tedious and not very accurate, since oxidation products are partially soluble in petroleum ether.

Polar compounds:

The heated fat is fractionated on a silica gel column and the non polar fraction is eluted with a petroleum ether diethyl ether mixture. The percentage weight of the polar fraction is calculated by difference. A value of 27% polar components is suggested as the maximum tolerable for usable oil.

Dimer esters :

The technique involves complete conversion of the oil to the corresponding methyl esters followed by separation and detection on a short column in a gas chromatography. The increase in dimer esters is used as a measure of thermal decomposition.

Quick Tests :

Changes in the dielectric constant of the oil can be measured quickly is an instrument known as the Food oil sensor. The dielectric constant increases with an increase in polarity and increased polarity is used as an indicator of deterioration. Good manufacturing practices include.

- 1. Choice of frying oil of good quality & consistent stability
- 2. Use of property designed equipment
- 3. Selection of the lowest frying temperature consistent with producing a fried product of good quality
- 4. Frequent filtering of the oil to remove food particles.
- 5. Frequent shutdown and cleaning of equipment.
- 6. Replacement of oil as needed to maintain high quality.
- 7. Consideration of antioxidant use. When used, the level of antioxidant will sometimes decrease rapidly, and this is important to monitor.
- 8. Adequate training of personnel.
- 9. Frequent testing of the oil throughout the frying process.

Lecture No: 27

Antioxidants – Natural & synthetic oxidants, Mechanism of action, examples and mode of application.

Definition:

Antioxidant is a substance added to fats and fat containing substances to retard oxidation and there by prolong their wholesomeness, palatability and sometimes shelf life.

Natural antioxidants :

The natural antioxidants present in foods inhibits formation of anti carcinogenic nitrosamines. Some commonly used natural antioxidants are

Tocopherols:

There are the most widely distributed antioxidants is nature and they constitute the principal antioxidants in vegetables oils. A relatively high proportion of the tocopherol present in crude vegetable oils survives the oil processing steps and remains in sufficient quantities to provide oxidative stability is the finished product.

Synthetic antioxidants:

The most commonly used synthetic antioxidants are

Butylated hydroxyanisole (BHA):

It is commercially available as a mixture of two isomers and has found wide commercial use in food industry. It is highly soluble in oil & exhibits weak antioxidant activity is vegetable oils, particularly those rich in natural anti oxidants. BHA is relatively effective when used in combination with other primary antioxidants. BHA has a typical phenolic odour that may become noticeable if the oil is subjected to high heat.

Tertiary Butyl hydroquinone (TBMQ) :

TBHQ is moderately soluble in oil and slightly soluble in water. In many cases, TBHQ is more effective than any other antioxidant in providing oxidative stability to crude and refined polyunsaturated oils without problem of colour or flavor stability. TBHQ is also reported to exhibit good carry – through characteristics in the frying of potato chips.

Mechanism of action of antioxidants:

The important lipids involved in oxidants are the unsaturated fatty acids, moiety oleic, linolic & linolenic acid, the rate of oxidation of

fatty acids increases the degree a unsaturation. The overall mechanism of lipid oxidation consists of 3 phases.

Initiation : Formation of free radicals.

 $RH + O_2 \longrightarrow R^0 + O4^0$

Propagation : The radical chain reactions

 $R^{0}+O_{2} \longrightarrow ROO^{0}$ $ROO+RH \longrightarrow R^{0}+ROOH$ $ROO^{0} \longrightarrow R^{0}+OH^{0}$

Termination :- Formation of non-radical products

 $R+R \longrightarrow R^{0}R^{0}$ $R + ROO^{0} \longrightarrow ROOR$ $ROO^{0} + ROO^{0} \longrightarrow ROOR + O_{2}$

Anti-oxidants can act against lipid per oxidation in 6-phases. They are

- 1. Decreasing localized O_2 concentration
- 2. Scavengeting spices that initiate per oxidation by the obstruction of hydrogen.
- 3. Quenching singlest O_2 to prevent the formation of peroxides.
- 4. Binding metal ions informs that will not generate reactive spices.
- 5. Decompose lipid peroxide to peroxyl.
- 6. Peroxyl removal.
- 7. Chain breakage to prevent mono hydrogen abstraction from fatty acid side chain.

Mechanism of action of synthetic anti-oxidants:

Anti-oxidants react with peroxy and oxy free radicals formed in lipid oxidation forming a hydro peroxide molecules & a free radical of the anti-oxidants, these free radicals formed from antioxidants are relatively stable so that they don't initiate a chain-anti-oxidant reaction.

Free antioxidant radicals are deactivated by reaction with a lipid peroxy ion alkoxy radical (or) with an other antioxidants radical dimmers are formed. By the action of some syneridges such as ascorbic acid, the original antioxidant may be regenerated.

Antioxidants containing a phenolic group play the major role in foods. The radical forms of antioxidants are stabilized by an aromatic resonance system. In contrast to the acyl peroxy & oxy free radicals they are not able to abstract hydrogen atom from an USFA & can initiate lipid peroxidation.

The end products formed in reaction are relatively stable & in consequence the auto oxidation radical chains are shortened. Antioxidants in addition play main roles s radical, scavengers can also partially reduce hydroperoxides to hydrogen components.

Lecture No: 28

Rancidity and its types, detection types.

Rancidity in fats and oils:

Rancidity is the term used to represent the deterioration of fats and oils resulting is an unsaturated fatty acids are more susceptible to rancidity. There are 3 main types of rancidity.

a. Hydrolytic Rancidity :

Hydrolysis of fats by lipase need not always produce off flavours. In case of butter fat and coconut oil, butyric acid and other low molecular weight fatty acids are set free by hydrolysis by lipase. The odours of these acids contribute largely to the smell of rancid butter. The higher fatty acids such as palmitic and stearic acid have little odour.

b. Oxidative Rancidity :

This is the common type of rancidity observed in all fats and oils. The oxidation takes place at the unsaturated linkage certain metals. Eg: copper hasten the onset of oxidative rancidity. The addition of oxygen to the unsaturated linkage results in the formation of peroxide which on decomposition yields aldehydes and ketones having pronounced off flavor.

Ketonic rancidity :

This type is most frequently encountered as a result of action of fungi such as Aspergillus Niger, Pencillium glaucum on coconut or other oilseeds.

The tallowy odour developed may be due to aldehydes and ketones formed by the action of the enzymes present in the fungi on oils. **Detection Types:**

The more common tests are

- 1. Peroxide value
- 2. Determination of carbonyl compounds
- 3. Active Oxygen determination
- 4. Thiobarbituric acid (TBA) test
- 5. Schaal oven test

All of the tests for peroxide value measure the amount of iodine's released when potassium iodide reacts with rancid fat. The lea method uses one gram of fat & 1 gm of potassium iodide with an acetic acid – chloroform(2:1) solvent. After heating the iodine formed is determined by titration with standard thio sulphate. Other methods modify quantities of solvent but the principle remains same.

The measurement of carbonyl compounds has followed traditional methods for this group. Today 2,4 dinitrophenylhydeazine is commonly used in the lapp in clarck method. Active oxygen is a method which measures the length of time required to produce 20 meq (milliequivalents) peroxide for 100 gm fat when air is bubbled through fats under standard condition.

In the TBA method for determining rancidity, an oxidized or rancid fat will react with 2 thiobarbituric acid (TBA) to form a red colour, the intensity of which is proportional to the amount of rancidity. In the recent years this has been developed into a method for measuring the extent of rancidity in a sample of fat. In the rancid fat the compound formed which reacts with the 2- thiobarbituric acid malonaldehyde.

The oven test is widely used in the baking industry it takes little equipment & is very easy to setup. Biscuits, cookies or crackers are stored in beakers or jars with loose fitting tops at 63^oC. The no. of days required to develop rancidity is measured by odour & taste. The temperature is slightly above what might be encountered during distribution of the food through regular commercial channels. Its greatest use in comparing fats.

Lecture No: 29

Enzymes in food industry – carboxylases, Amylases, cellulasess, hemicellulasess etc.

Enzymes used in food Industry:

Our food industry uses a variety of enzymes for processing of various foods.

For Eg : * Use of enzyme "Lactase" in dairy industry

- For the production of various types of syrups from starch and sucrose.
- Enzymes that are used in baking industry & brewing industry.
- 1. Uses of Enzymes Glucose oxidase catalase :

Source :

It is obtained from Aspergillus niger & pencillin. Catalyses the formation of gluconic acid from β – W-glucose in 2 separate steps:

Glucose

 β -W-glucose + O₂ \longrightarrow w-glucano-1,5-lactone + H₂O₂

Oxidase

D-glucono-1,5-lactone + H₂O Spontaneous

catalase $2 H_2O_2 \longrightarrow 2H_2O + O_2$

Hydrogen peroxide effectively kills bacteria & it can be eliminated by using "catalase" enzyme which breaks it down into $H_2O \& O_2$

Uses:

- Glucose oxidase is used for the removal of oxygen from food stuffs in order to enhance their stability.
- Application of these enzymes is in the processing of egg white for using in baking industry.
- Removal of O₂ from air present in the head space of bottles & canned drinks.
- Reduction of non enzymatic browning in wines.

Lecture No: 30

Uses of proteases :

Enzyme	Used in	Action
1. Endogenous	Meat	Tenderisation of
Proteases		meat & flavor
		development.
2. Subtilisin	Soya protein	Partial hydrolysis &
		increase whipping
		organisms on &
		emuls capacity.
3. Papain	Meat	Injection into jugular
		vein shortly before
		slaughter, after
		slaughter enzyme is
		activated tenderizes
		the meat.
4. Meat liable	Dough from high	Hydrolysis of glutein
fungal process	glutein wheat	makes the dough
	varieties	suitable for biscuits
		pasty making.

Uses of lactose enzyme in dairy industry:

Milk & whey contains 4-7% lactose. Lactose is hydrolysed by the enzyme lactose which produces the monosaccharide's D-glucose & β - ω -galactose.

Lactose + H_2O ω -glucose + β - ω -galactose

Sources :

- From dairy yeast klucteromyces tragilis (suitable for treatment of milk)
- From A.niger (or) A.oryzae-added to milk or whey incubated at 5⁰C for 1 day 50% lactose gets hydrolysed making milk (or) whey sweet.

Uses :

- Used in production of ice creams, sweetened flavors, condensed milk.
- Lactose treated whey powder in ice creams recipes which improves creaminess of ice creams.

Enzymes used in fruit juice & Brewing Industries:

The cloudiness of fruit juices and wines is mainly due to hetero polysaccharides pectin which exhibit usually associated with other plant polymers & cell debris.

- Pectin's are digested by proteolytic enzymes prepared from A. Niger.
- These enzymes preperations are mixes of polygalacto urinase (digestion of pectin), Pectin esterase (removal of methyl esters & release of methanol), pectin lyase (cleaves pectin into oligosaccharides without pectin esterase unit).
- Degrades hemicelluloses.

Treatment of fruit pulp with proteolytic enzymes mixture give the following benefits :

- 1. Elimination of juice or wine cloudiness.
- 2. Reduced solution viscosity
- 3. Increases juice yield

4. Decreases fermentation time in case of wine.

Pectin's stabilize cell debris in colloids stable but once these pectin's are digested, the debris precipitates and it is removed by filtration.

The following enzymes are employed in beer production to achieve specific objectives.

- 1. α -amylases & β -gluconase are used for increased & rapid saccharification.
- 2. Neutral proteases are added to the wort to hydrolyse proteins and to increase the fermentation rate in the later stages.
- 3. Cellulases are used to digest barley glucans, particularly when wheat is used as an adjunct.
- 4. Papain is added to beer during the latee past-fermentation stages to hydrolyse the proteins & prevent the occurrence of chill-haze.
- 5. Gluco amylase (or) fungal α -amylase are used during fermentation to produce "low calorie" or "light beer"
- 6. A variety of distilled alcoholic drinks Eg: why beer, rum, vodka are prepared by fermentation of a large no. of substrates rich in Cho's. some of these substrates Eg: molasses crum), grapes (brandy) etc are rich in fermentable sugars. In such cases, heat stable α -amylases from bacteria are used for sacharification.

Gluco Amylose:

- It acts on starch, dextrins & sugars by cleaning the α -1, 4 glucosidic linkages releasing stepwise from the end of the chains.
- It is widely used in the manufacture of glucose and for conversion of CHO's to fermentable sugar.

- They play a major role in the starch, sugar & alcohol.
- Glucoamylase is divided into two types
- 1. Fungal gluco amylases : Capable of hydrolyzing glycosidic linkages of starch.
- 2. Glucoamylase & pullulanase : Blend for higher glucose yields from starch

Cellulases :

Cellulase acts on cellulose molecules by hydrolyzing the β -1,4-glycosidic linkage.

Amylases :

Amylases acts on starch (Amylose to Amylopecton). They split starch into dextrins & sugars by clearing the α -1, 4-Glycosed linkages. Amylases can be divided from fungi & bacteria. They play a major role in foods & beverages, baking, brewing, starch & sugar and alcohol.

Types of amylases:

- Alpha amylases
- Fungal α -amylases : For detoxifying & sectionifying of starch.
- Bacterial α-amylases:

-For starch liquefaction up to 90°C

-They are thermo stable.

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Enzymatic reactions of interest to food processing

Enzymes & their application in food industry:

Enzyme	Source	Applications
β-glucanase	Trichoderma	-Aids mash filteration in brewing
		by reducing viscosity.
Acetolactate	Aerobacter	-Reduction the production times
Decarbosylase	Aerogenes	beer from 5weeks to 2weeks 6
		avoiding the formation of
		diacetyl.
α-Glucosyl	Protaminobact	_
transferase	er	-Rearrangement of sucrose to
	Robrum	isomaltose, a non-caecinogenic
		nutritive sweetener.
Sulphydryl	Asporgillus	strongthoning work dough from
Ovidase	niger	low gluten flour
Oxidase	inger	
Urease	Lactobacillus	-Reduces urethane,
	Fermentum	acarcinogenic in sake.
α -Glactosidase	Aspergillus	-Modified guar galactomanna to
	niger	mimic locust bean gum
Amylases	Bacteria	-Starch hydrolysis into dectris
	(Bacillus sp)	maltose & glucose
	Fungi	-Removal of starch
	(Aspergullus	-Saccharification of starch for
	sp)	Alcohol production.
	_ .	-proper volume in baked goods
Cellulase	Fungi	-Hydrolysis of cellulose into
	(trichoderma	Glucose
	reesii)	-Ethanol production.

Glucose isomerase	-Bacteria	-Production of high fructose Corn syrup.
Glucose oxidase & catalase	Cornybacteri umspp	-Removal of O₂ & anti sepsis of Foods.
Invertase	Yeast (sacchaeomyc es cerevisae)	-Production of invert sugar from sucrose.
Naringinase	Fungi(Aspergill us niger, coniclla diplodiella)	-Sugar confectionary, chocolate -Webittering of fruit juices Especially citrus.
Pectinases	Fungi(Aspeegil lus spp) (polygalactura nases)	-Clarification of wines & fruit juices - viscosity reduction in fruit processing.
Proteases	Bacteria(Bacillus sps) Fungi(Aspergill us spp) Yeast (sacchacomyc es spp)	 -Dough production -Say sauce -lysis of plant proteins -Removal of protein clouds in Fermentative beverages.
Pullulananes	Bacteria	-Peptone manufacturing.