



IIT KHARAGPUR



NPTEL ONLINE  
CERTIFICATION COURSES

# Dairy and Food Process and Products Technology

PROF. TRIDIB KUMAR GOSWAMI

AGRICULTURAL AND FOOD ENGINEERING DEPARTMENT

IIT KHARAGPUR

Lecture 31

<b>Amino Acid</b>	<b>Short form</b>	<b>Cio de</b>	<b>20 A M I N O  A C I D S</b>	<b>Amino Acid</b>	<b>Short form</b>	<b>Cio de</b>
<b>Alanine</b>	<b>Ala</b>	<b>A</b>		<b>Methioni ne</b>	<b>Met</b>	<b>M</b>
<b>Cysteine</b>	<b>Cyc</b>	<b>C</b>		<b>Asparag ine</b>	<b>Asn</b>	<b>N</b>
<b>Aspartic acid</b>	<b>Asp</b>	<b>D</b>		<b>Proline</b>	<b>Pro</b>	<b>P</b>
<b>Gltamic acid</b>	<b>Glu</b>	<b>E</b>		<b>Gltamin e</b>	<b>Gln</b>	<b>Q</b>
<b>Phyalanin e</b>	<b>Phe</b>	<b>F</b>		<b>Arginine</b>	<b>Arg</b>	<b>R</b>
<b>Glycine</b>	<b>Gly</b>	<b>G</b>		<b>Serine</b>	<b>Ser</b>	<b>S</b>
<b>Histidine</b>	<b>His</b>	<b>H</b>		<b>Threoni</b>	<b>Thr</b>	<b>T</b>

19 are primary amines, 1 (proline) is a secondary amine  
19 are “chiral”, 1 (glycine) is achiral; the natural  
configuration of the  $\alpha$ -carbon is L.

“Chiral” - asymmetric in such a way that the structure and its  
mirror image are not superimposable.

# WHEY PROTEINS

- **Whey proteins contain hydrophilic amino acids forming globular, highly ordered, proteins that contain disulfide linkages.**
- **Whey proteins have well-developed secondary, tertiary, and quaternary structures.**
- **Poorer heat stability: denature at temperatures greater than 75 °C.**

**Hydrophilic amino acids:** Aspartate, Glutamine, Glutamate, Histidine, Lysine, Serine, Arginine, Tyrosine, Tryptophan, Threonine, Cysteine

Two Primary whey proteins are:

$\alpha$ - **Lactalbumin** and  $\beta$  – **Lactoglobulin** which are synthesized in mammary gland - approximately, 20% and 40% of total whey protein in bovine milk.

**Other whey proteins are**

- Proteose peptones**
- Immunoglobulins**
- Serum albumin**

## ■ Albumin or lactalbumin

– resembles but not identical with blood albumin, dried form is a tasteless powder, chemically extremely complex like other proteins,

– contains 'S' twice that of casein, contains no phosphorus

### $\alpha$ - Lactalbumin

➤  $\alpha$  - Lactalbumin is a spherical, glycosylated compactly folded calcium metalloprotein

➤ Consists of approximately **142 amino acids** and is

- **approximately of 14 kDa in size.**
- **It is synthesized and secreted by the mammary gland.**
- **It contains four disulfide bonds and eight cysteine residues and is rich in tryptophan**
- **Three genetic variants have been identified.**
- **It is the principal protein in human milk.**

## **$\beta$ -Lactoglobulin**

- ✓  **$\beta$ -Lactoglobulin consists of 178 amino acids with an approximate molecular weight of 18 kDa.**
- ✓ It exists in both the monomeric and dimeric form at equilibrium in bovine milk.
- ✓ Its association depends on temperature, pH, protein concentration, and ionic conditions.
- ✓ **The hydrophobic dimeric form linked by one to three disulfide bonds is approximately 36 kD.**
- ✓ Higher concentrations of  $\beta$ -Lactoglobulin are present in bovine milk compared to that in human milk.

# Thank You!!





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- ✓  $\beta$ -Lactoglobulin is better in terms of heat stability than that of  $\alpha$ -Lactoglobulin due to the presence of free sulphhydryl unit.
- ✓ It contains an open  $\beta$  – barrel enclosing a hydrophobic cleft and a single three turn  $\alpha$  - helix.
- ✓ It binds to several hydrophobic molecules including retinol and fatty acids via the hydrophobic cleft, which in turn stimulates lipase activity.

**Immunoglobulin** – antibodies that are synthesized in response to specific antigens.

**Antibodies**, also called immunoglobulins, Y-shaped molecules are proteins manufactured by the body that help fight against foreign substances called **antigens**. **Antigens** are any substance that stimulates the immune system to produce **antibodies**. **Antigens** can be bacteria, viruses, or fungi that cause infection and disease.

**Immunoglobulins are large, heterogeneous molecules found in the blood. The main immunoglobulins in milk are**

IgG, IgG2, IgA, and IgM.

Immunoglobulin G (**IgG**), the most abundant type of antibody, is found in all body fluids and protects against bacterial and viral infections. Immunoglobulin M (**IgM**), which is found mainly in the blood and lymph fluid, is the first antibody to be made by the body to fight a new infection.

Immunoglobulins provide offspring with protection against pathogens and their toxins, and the mammary gland against infection.

In bovine milk, approx. 0.7 to 1 mg / ml is present in bovine milk. Structural unit of immunoglobulins are similar.

Two heavy and two light chains are joined together by disulphide bonds. IgG is the main immunoglobulin in milk.

**SERUM ALBUMIN:-** 582 amino acids. Longest protein. Approx. 66 kDa.  $\alpha$  - helix is predominant. It is 1 to 5 % of total whey protein. Synthesized in the liver and enters the milk via secretory cells.

**Proteose and Peptones :-** derived from the hydrolysis of  $\beta$  – casein. But considered whey proteins – bcz, it elutes in the whey fraction when isolated from milk. It is heat stable, acid soluble protein, responsible for foaming of milk, inhibits rancidity, has an immunological role.

**Protease:** A protease is any of various water-soluble compounds that are produced during digestion by the hydrolytic breakdown of proteins short of the amino acid stage.

**Peptone:** a soluble protein formed in the early stage of protein breakdown during digestion.

**Peptide:** a compound consisting of two or more amino acids linked in a chain, the carboxyl group of each acid being joined to the amino group of the next by a bond of the type  $-OC-NH-$ .

Basic definition is **similar**. **Peptone:** a soluble protein formed in the early stage of protein breakdown during digestion. Pepsin converts proteins to **peptones**, **protease** and peptides. Peptide has a different definition, but it can be applied to the other two too as all are degraded proteins but not amino acids.

# Thank You!!





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Lactoferrin:- Globular glycoprotein. 74 kDa and binds to iron (Fe) as it contains two metal binding sites. Bovine milk contains approximately 20 to 200 mg / litre. Human milk contains 2 g / litre

Other minor whey proteins includes: - GROWTH FACTORS, VITAMIN BINDING PROTEINS like Folate, Vitamin D, Riboflavin, and Vitamin B 12; ANGIOGENINS, OSTEOPONTIN.

– unlike casein coagulates by heat treatment, but not by rennet, may be in colloidal state or in true solution.

– Commercial use

- is yet to be established.

• Other proteins:-

- » lactoglobulin,
- » fibrin,
- » alcohol soluble proteins.

## CARBOHYDRATES:

Several carbohydrates are there in milk such as LACTOSE, GLUCOSE, GALACTOSE, GLYCOCONJUGATES (Oligosachharides, glycoproteins, glycoaminoglycans). MAIN CARBOHYDRATE is LACTOS – 4 to 45% total in milk. Glucose, galactose, oligosaccharides – approx 1 mg / ml

### Milk sugar or Lactose:-

A disaccharide composed of  $\alpha$  - lactose monohydrate,  $\beta$  – lactose, anhydrous  $\alpha$  - lactose

$\beta$  – lactose has greater solubility and is sweeter than  $\alpha$  - lactose .

Major food source for bacteria during fermentation of food is  $\beta$  – lactose .

Bacteria hydrolyze milk into glucose and galactose to produce lactic acid, which inhibits the growth of most other microorganisms,

**Solubility of lactose is 1/3rd of sucrose at 100 °C,**

**Prolong heating at 100 - 310 °C results in a decomposition indicated by a light – brown or caramel colour.**

- In the presence of bacteria it is easily decomposed as:
  - $C_{12}H_{22}O_{11} + H_2O (+bacteria) = 4C_3H_6O_3$  (lactic acid).
- **1g of lactose on bacterial decomposition forms**
  - **0.8 g of lactic acid.**
  - In general, 10 to 30% of the sugar is used in the normal souring of milk.
- **Dry milk contains a very high percentage of lactose, approximately 38%.**
- **Because it is dried instantaneously lactose does not crystallize but forms a lactose 'glass' (highly concentrated viscous soln),**

very hygroscopic, under high RH will rapidly take up water diluting lactose glass to the point where it becomes sticky and finally crystallization of alpha-lactose occurs resulting to a hard caked powder which is a serious defect in the product.

■ **Ash or mineral matter:-**

- **Milk ash contains K, Na, Ca, Mg, Cl<sub>2</sub>, P, S in relatively large amounts.**
  - **Very small amounts of Fe, Cu, Zn, Al, Mn, Co, I<sub>2</sub>,**
  - **and traces of Silicon, Boron, Titanium, Vanadium, Rubidium, Lithium, and Strontium are present.**
  - **Parts of Ca, and P are combined with proteins.**
  - **Remaining portions together with Mg are partly in suspension and partly in solution.**
  - **Small portion of S enters into the composition of the Casein and Lactalbumin.**
- **Milk is low in Fe and for this reason would not supply all the needs of an adult.**

Minerals in milk is about 0.7 to 0.8%. Na, K, and Cl as free ions which are readily diffusible and their concentrations are negatively correlated with lactose.

Concentrations of Ca, Mg, ionized phosphate and citrate depend on the casein content in milk.

Concentration of citrate varies depending on season and feed of the animal (cow), which affect the soluble calcium content and milk stability, equilibrium between colloidal dispersion and salts.

If the colloidal equilibrium is destabilized, [minerals] may affect the processing, which require addition of anions to bind to ionic calcium that would restabilize the casein against aggregation.

# Thank You!!





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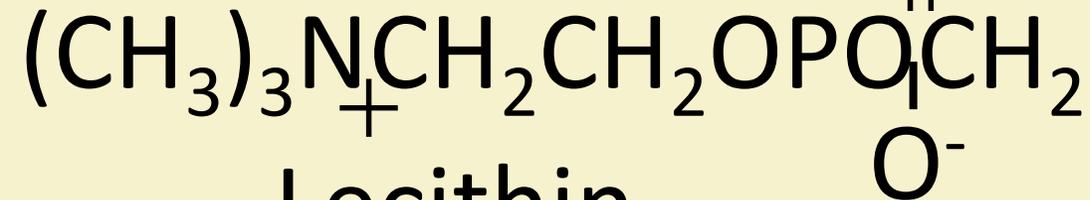
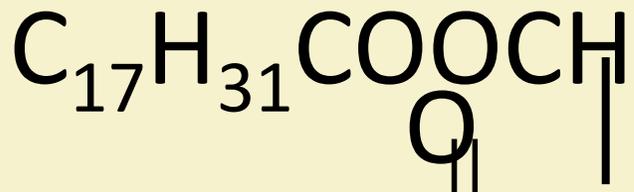
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Salt is added as an additive in certain dairy products. The concentration of calcium in milk is relatively high and for this reason milk is considered to be an important source of calcium. Primary salts in milk are phosphates, citrates, chlorides, sulphates, carbonates and bicarbonates of Na, K, Ca, and Mg. Ofcourse, level of salt is not equivalent to the level of minerals. Level of salt is also by no means equivalent to ash content. Influencing factors for salt composition are Species, breed of species, stage of lactation and feed.

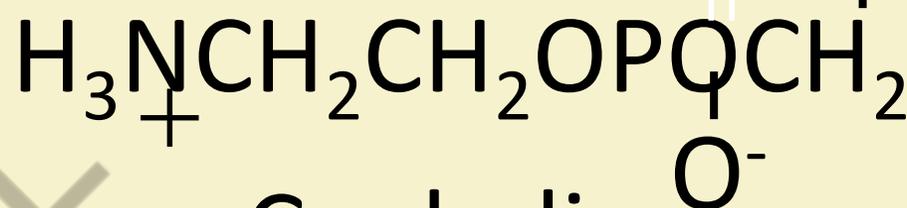
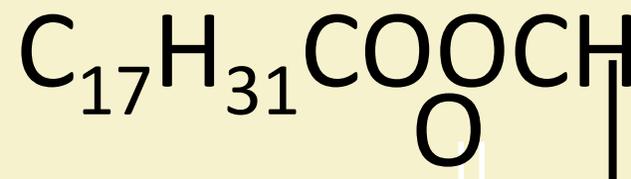
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- » Milk is low in Fe and for this reason would not supply all the needs of an adult.
- Minor constituents:-
  - Yellow colour of milk is due to a pigment known as **Carotene**.
  - **Phospholipids** – lecithin (fat like substance containing  $N_2$  and P).
  - **Fishy flavour** of butter, a common defect is due to the decomposition of *lecithin*.
  - In the splitting of lecithin, trimethylamine is formed, which is responsible for fishy flavour.

## ■ Cholesterol:-

- Milk contains 105 to 176 parts per million. Pigments:-
- Two – fat soluble (carotenoids) and water soluble (riboflavin).
- Feeds as green grass, green alfa-alfa hay, green silage and carrots etc. are rich in carotene.
- Riboflavin previously called lactoflavin or lactochrome contributes a yellowish green tint to the whey.



Lecithin



Cephalin



Cholesterol

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Milk Enzymes:- 20 enzymes have been characterized. 40 more enzymes their presence via their activity. Indigenous milk enzymes are found in, or associated with (A) casein micelle, (B) fat globule membrane, and (c) milk serum or somatic cells. These enzymes may originate from blood, somatic cells, MFGM, cell cytoplasm.

Enzymes serves two purposes as indicators; - (!) Health of the Animal, (2) Thermal history of the milk.

Functions of enzymes in milk and dairy products are :- (1) can deteriorate quality, (2) can induce desirable changes, (3) can offer protective effects.

- **Enzymes:-**
- **Ptyalin of the saliva which acts on starch forming maltose,**
- **Pepsin in the stomach which assists in breaking down of the proteins,**
- **Galactase a proteolytic enzyme, acts in ripening of cheese,**
- **Lipase, a fat-splitting enzyme,**
- **Catalase, an oxidizing enzyme**
- **Reductase, a reducing enzyme,**
- **Lactase, a sugar fermenting enzyme,**
- **Diastase, a starch-splitting enzyme,**
- **Peroxidase, an oxidizing enzyme,**
- **Phosphatase, an enzyme to test for evaluating the effectiveness of pasteurization.**

# Thank You!!

