##  Sengamala Thayaar Educational Trust Women’s College

## (Affiliated to Bharathidasan University)

**(Accredited with ‘A’ Grade {3.45/4.00} By NAAC) (An ISO 9001: 2015 Certified Institution)**

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**FOOD CHEMISTRY**

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**FOOD CHEMISTRY**

**CHEMICAL REACTION OF LACTOSE**

**21.1 Introduction**

Milk products are especially sensitive to the effects of heat treatment encountered under conventional process and storage conditions because of an abundance of reactive functional groups: aldehyde group of lactose, ε -amino group of lysine and other reactive N-containing groups (e.g. indolyl group of tryptophan, imidazole group of histidine, guanidine group of arginine and theα-amino group of proteins and free amino acids). The most important heat induced changes in dairy products that involve lactose are the changes associated with browning. Milk is the only important naturally occurring protein food with a high content of reducing sugar. Lactose may isomerize or it may react with protein in milk. The reaction of lactose with the caseins and whey proteins of milk systems will be *via*the Maillard or non-enzymatic browning reaction. It is also referred to as glycosylation of proteins for e.g. in case of lactose it is known as lactosylation ofproteins.

**21.2 Maillard Type Browning**

Generally Maillard type browning, is detrimental to the organoleptic, nutritional and functional qualities of the product and are therefore undesirable. However this reaction is being utilized favourably in the preparation of products like khoa where milk is heated in the presence of sucrose to produce brown product with a pleasant flavour. Maillard reaction also plays an important role in the generation of flavour during the manufacture of ghee or clarified butter and milk chocolate.

**21.2.1 Reaction mechanism and pathway of maillard reaction**

The first step in the Maillard reaction involves the nitrogen atom of an amino compound and carbonyl group of an aldehyde, or ketone in food systems and the reactants are predominantly protein and reducing sugars. In some situations the carbonyl products of lipid peroxidation, vitamin C, free amino acids and ammonia are also important reactants. The reaction proceeds with the elimination of a molecule of water to form a Schiff’s base which subsequently rearranges to for man N- substituted glycosylamine intermediate. The amino acid carboxyl group plays an important role in the catalysis of the Amadori rearrangement. Thus the N-substituted glycosylamines derived from the amino acids are inherently unstable and they are either hydrolysed to the parent amino acid and reducing sugar or react via a spontaneous rearrangement to form the corresponding keto–(α-1-amino-1-deoxy-2-ketose) or aldo (α-2-amino-2-deoxyaldose) derivative depending on whether the parent sugar is an aldose or a ketose respectively. The aldo to keto transformation is referred to as the Amadori rearrangement and the corresponding keto to aldo rearrangement as the Heynes rearrangement.

The Maillard-type browning, sugar-amino type is the most prevalent, since it requires relatively low energy of activation and is auto catalytic. Direct caramelization, on the other hand, has a rather high energy of activation and therefore is less important. Lactose and casein are the two principal reactants in the browning of milk products, but dried whey products containing lactose also undergo browning. Roller-dried products showed significant losses inlysine content, due to the contact with the drums with high temperatures. The protein-carbohydrate complex or its decomposition products result in the production of reducing substances, fluorescent substances, and disagreeable flavour materials. For example, 40 compounds were isolated and identified from a model system of casein and lactose that a product which had been stored at 80°C and 75% relative humidity for 8 days to accelerate browning. Substances which are isolated are furans, lactones, pyrazines, pyridines, acetylpyrrole,amines, pyrrolidinone, succinamide, glutarimide, dicarboxylic acid, acetone, 2-heptanone, and maltol were identified in the brown mixture, along with D-galactose, D-tagatose, and lactulose.

In milk products, active sulfhydryl groups serve as natural inhibitors in retarding heat-induced browning, but their mechanism is not understood. Sodium bisulfite,sulfur dioxide, and formaldehyde also inhibit browning in milk systems as well as in simpler mixture of amino acid and sugar solution. In actual practice, browning in dairy products is controlled by limiting heat treatments, moisture content, and time and temperature of storage. Browning has detrimental effect on the nutritive value of food products through interaction of the free €-amino group of lysine in the proteins with carbohydrates and the resultant rearranged product. Destruction of essential amino acids, particularly lysine and probably histidine, has been shown to occur during the storage and browning of non fat dry milk with high moisture (7.6%) content. Similar powders of low moisture (3.0%)did not deteriorate in nutritive value during storage. Reaction ofβ-lactoglobulin with lactose in the “dry state” (10% moisture) resulted in various degrees of lysine destruction, depending upon temperature and heating times. Arginine, histidine, acidic and neutral amino acids were not damaged by the thermal treatments (0 to 90°C) in the presence of lactose.

**21.2.2 Factors that influence maillard reactions**

The overall rate and product profile of Maillard reaction in foods are highly dependent on number of parameters, however the most important are listed below:

• Reactants
• pH
• Temperature
• Moisture content
• Water activity

***21.2.2.1* *Reactants***

The nature and the molar concentration of the reacting species have considerable influence on the rate and mechanism of the Maillard reaction. Low molecular weight reactants tend to react more readily than high molecular weight reactants. Glucose is more reactive than lactose and contribute to the increased rate of browning In lactose hydrolysed milks

***21.2.2.2* *pH***

The rate of Maillard reaction increases with increasing pH,maximum upto 9-10 depending upon the type of amino acids involved. Bases can catalyse the initial steps of the carbonyl amine reactions by removing the proton from the nucleophile increasing the nucleophilicity. The browning of pure Amadori product is also accelerated at alkaline pH values. pH exerts a considerable influence on the mechanism of the Maillard reaction by determining the type of enolization favoured(1,2 or 2,3-enolization) and hence the pattern of the Amadori compound degradation.

***21.2.2.3* *Moisture content and aw***

Both moisture content and the aw of a food system exert a major influence on the Maillard reaction. Water my influence the rate of reaction by controlling the viscosity of the liquid phase and by dissolution concentration or dilution of reactants. At a very low aw value the proportion of the total reactants in solution is negligible and therefore the reaction rate is minimal. As the aw increases the concentration of remains constant provided excess solute is available to maintain saturated solution. However the total volume in which the reaction takes place increases.

***Miscellaneous factors***

Phosphate, citrate and phthalate buffers have been shown to accelerate the Maillard reaction. In the 5-7 pH range, phosphate has a dramatic effect on reaction rate (increasing up to 15 fold) as compared to that of phosphate free system.