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Effect of Maillard Reaction on Quality and Nutritional Parameters of Food Products

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SUMMARY

Maillard reaction is a form of non-enzymatic browning reaction that occurs between Ɛ-amino group of amino acids and carbonyl group of reduced sugars during thermal treatments of foods. During the reaction some products are produced knowns as Maillard reaction product (MRPs), which are largely responsible for the development of color, taste and especially aroma of thermally treated foods. Color development of thermally treated products is mainly attributed to the formation of brown polymers called melanoidins. The higher temperature and longer reaction time result into a marked increase in flavor formation. However, MRPs also reduce the nutritional quality of foods by reducing protein digestibility, destruction of essential amino acids and the production of anti-nutritive and toxic compounds.

INTRODUCTION

Brown color is produced during thermal treatment of food due to non-enzymatic browning as a result of Maillard reaction. Maillard reaction plays an important role in the formation of flavor and color of heated food. It occurs between the carbonyl group of reducing sugar and Ɛ-amino group of amino acids during the processing or storage of food. The rate of Maillard reaction is affected by time and temperature of heating, hydration, pH, water activity and concentration of protein and sugar etc. (Aljahdali and Carbonero, 2017). The Maillard reaction was first described by Louis-Camille Maillard in 1912, while conducting pioneer work on sugar-amino acid condensations. He reported that the development of yellow-brown color during heating of sugars and amino acids in water (Kumar et al. 2013). During the Maillard reaction several compounds are produced known as Maillard reaction products (MRPs) such as Hydroxymethylfurfural, Furfural, Pyrazine, Reductone, etc. These compounds are responsible for a change of colors, odors, flavors and loss of nutritional quality of the food product. The principle component responsible for colour is melanoidin (Figure 1).

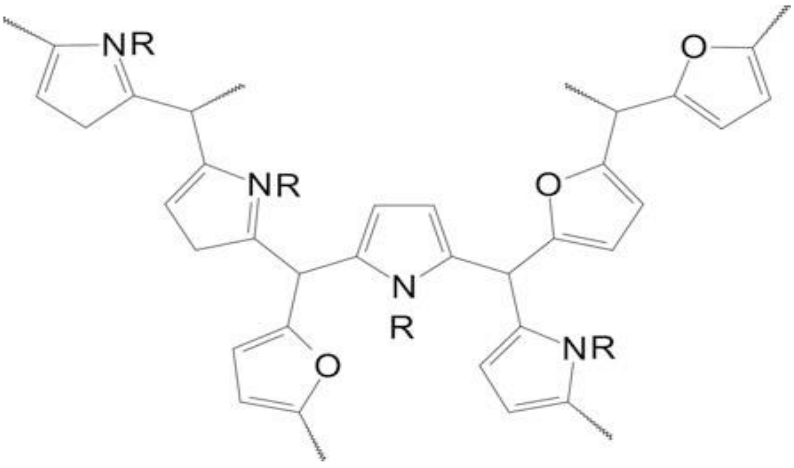

Figure 1 Melanoidin

Effect of Maillard Reaction on Quality, Nutrition value of food

The effect of Maillard reaction on food product is important as MRPs not only influence the color and flavor of food, but also its nutritional value which influences health of human.

Quality

Quality of product is a very important factor because it affects the accepting or rejecting characteristic of a product. The flavor, color and texture of the product is affected during the Maillard reaction.

Flavor

In any food product the flavor is produced by the volatile compound and there are also nonvolatile compounds that participate in flavor formation; for example, salt and lactic acid in bread (Starowicz and Zieliński, 2019). In Maillard reaction the volatile compounds are produced by Strecker degradation reaction such as aldehyde, pyridines, pyrazines, oxazoles, thiazolesetc responsible for the formation of flavor which is depends on the type of sugars and amino acids involved, and on reaction temperature, time, pH and water content. MRPs responsible for flavor formation can be divided into three classes of molecules: oxygen-containing, nitrogen-containing and sulfur containing compounds and the quantity of the compound varies within the range 1 µg/kg to 100 mg, 0.001–10µg, and 1 µg to 1.5mg per kg of food sample respectively (Starowicz&Zieliński, 2019).

Color

The colour formation is the primary characteristic of the Maillard reaction during processing and storage of product. It is desirable for many products such as baked foods, coffee, cookies while undesirable in some kinds of food products orange juice, white chocolate, milk and powder. At the final stage of the Maillard reaction the color is developed by condensation of carbonyls and amines forms high molecular weight compounds, known as melanoidins (browning) (Starowicz&Zieliński, 2019).The color producing compounds are either unsaturated nitrogenous or nitrogen-free polymers and can be grouped into either low molecular weight pigments (two to four linked rings with extended double-bond conjugation) or high molecular weight melanoidins (molecular weight of several thousand daltons, with discrete chromophores). The methylene group of the furanone is undergoesaldol condensation with aldehydes, such as furfural and other aldehydes willalso condense and yellow to red color product is produced. Accordingly, dicarbonyl compounds should lead to crosslinking (Nursten, 2007).

Texture

‘‘Texture is the sensory and functional manifestation of the structural, mechanical and surface properties of foods detected through the senses of vision, hearing, touch and kinesthetics’’ and which is affected by the functional properties of the protein such as protein crosslinking formation, emulsions properties and protein–polysaccharides conjugates formation (Starowicz&Zieliński, 2019). Proteins glycation and aggregation processes responsible for bars hardening of protein, which was increasing during the storage. The replacement of reducing sugars with sugars alcohols can minimize the increase of hardness. Protein and polysaccharides conjugates addition (formed during MR), might successfully promote the quality of some food products through emulsion, gel and foam formation

Nutrition

When foodstuffs undergo MR, the nutritional value of food is reduced, and some proteins are lost or become non-digestible. Exposing glucose and lysine to different heating periods caused loss of lysine. The interaction between glycine and glucose reduced the protein efficiency ratio (PER) by 22%, which reduced digestibility of nitrogen and metabolism of proteins measured in animals. Nutritional losses occur during Maillard reaction are considered problematic in dairy, eggs and cereal products as thermal treatment or long-term storage conditions. Challenges include destruction of essential amino acids, decrease in protein digestibility and chelation of trace metals (Perez-

Protein digestibility

The amino acid bioavailability reduces during the Maillard reaction by direct interaction between proteins and sugars. The decrease in protein digestibility is another symptom associated with Maillard degradation of the nutritional quality of proteins. The proteolytic and glycolytic enzyme are blocked by chemical modify cation of protein-bound amino acid residues and reduce the hydrolysis necessary for digestion. The cross-linkingby peptide chain initiated via protein glycation prevents proteolysis by enzymes such as trypsin and carboxypeptidase (responsible for digestion) (Perez-Locas&Yaylayan, 2010).

Chelation of metal

Bioavailability of the trace metal is reduced by the Maillard reaction**.** In an in-vitro study, iron phosphorus bioavailability is reduced by the presence of MRPs in the diet. The magnesium digestion is reduced due to consumption of MRPs by 13% compared to non MRPs. Also antioxidant and antimicrobial properties are produced due to the binding of metal by MRPs (Morales et al., 2012).Such as higher chelating affinity is produced by the melanoidins obtained from glucose and glycine compared to melanoidins obtained from lactose and lysine and lactose N-acetyl lysine (Borrelli et al. 2002).The metal chelating ability of MRPs can be beneficial or problematic, depend on the circumstances and the type of product for example prevent the lipid oxidation (Perez-Locas&Yaylayan, 2010; Aljahdali and Carbonero, 2017), reduce the essential trace metals (Ca, Mg, Cu, Zn, Fe) and prevent the mineral metabolism and absorption. Two melanoidin residues, hydroxypyridone and hydroxypyranone, can complex with ferric ions. Absorption of Cu, Zn and Fe is decreased in human body by following intravenous infusion of MRP (Perez-Locas&Yaylayan, 2010; Aljahdali and Carbonero, 2017).

Essential amino acids

The nutritional value of foods is reduced through the destruction of essential amino acids and the production of antinutritive and toxic compounds. Food in which complete browning reaction is not occur and no off-flavor is produced, the nutritive value of the product reduced due to the formation of colorless Amadori compounds. Amadori compounds generally not have any nutritional value. The formation of Schiff s bases in the first steps of the Maillard reaction appear to be nutritionally equivalent to freeamino acids. The Amadori compoundsare a good source of nitrogen than the complete absence of amino acids. From Amadori compounds low levels of amino acids (<0.5%) are regenerated, while it appears that the gut microflora maybe responsible for the regeneration of free amino acids, but it is unclear how much. There are significant losses of sulfur amino acids, arginine, tryptophan and histidine may occur during the thermal treatment of food, which is depend on the severity of heat treatment.

CONCLUSION

Non-enzyme browning is undesirable during processing, manufacturing and storage of food but it is desirable in which food where dark colour is desirable such as bread, biscuits, cookies etc. The result or product of Maillard reaction deteriorate the quality of the product by degradation of the protein, production of the undesirable non-volatile compound, production of the antinutritional compound and losses of essential amino acids. It is important during the storage of the product keep at low temperature for preventing of non-enzymatic browning and to maintain the quality of the product.

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