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Processed Foods Where Maillard Reactions Occur Its Place in Our Nutrition and Health Dimension

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Abstract
The most important of the non-enzymatic browning reactions occurring in processed foods is the Maillard reaction. This reaction between glycine and glucose is a complex reaction, although it is first explained simply in this way. Maillard reaction causes colour, taste and odour changes in foods. Maillard reaction takes place even in home-made bread as well as in ready processed foods. This reaction, which occurs after heat treatment, is carried out to make foods long-lasting and to give desired properties such as colour to foods. In addition to these properties that it gives to foods, positive and negative properties occur in foods. Acrylamide released during the Maillard reaction is one of the carcinogenic substances harmful to food. This reaction, which negatively affects the nutrient content and quality, occurs in every heat- treated food and becomes important for every human being. When the negative properties are observed, it is seen that such ideas and applications are not favoured because of the undesirable and unpleasant effects on food, although efforts are made to reduce these effects. In addition to the negative features of the Maillard reaction reaction, positive features have also been found in the studies. In this study, the importance of Maillard reaction, which has an important place in foods, has been processed, information about acrylamide, which is a carcinogenic substance, has been given and the effects of reaction foods on our nutrition and our health have been mentioned.
Keywords: Maillard Reaction, Processed Foods, Acrylamide.

PROCESSED FOODS WHERE MAILLARD REACTIONS OCCUR ITS PLACE IN OUR NUTRITION AND HEALTH DIMENSION

Özet
İşlenmiş gıdalarda meydana gelen enzimatik olmayan esmerleşme reaksiyonlarından en önemlisi Maillard reaksiyonudur. Glisin ile glikoz arasında olan bu reaksiyon, ilk olarak basitçe bu şekilde açıklansada Maillard kompleks bir tepkimedir. Maillard reaksiyonu gıdalara; renk, tat, koku vermesi ile bilinmektedir. Hazır işlenmiş gıdalarda olduğu gibi evde yapılmış olan ekmekte dahi Maillard reaksiyonu gerçekleşmektedir. Isıl işlem sonrasında meydana gelen bu reaksiyon gıdaların uzun ömürlü olması ve gıdalara renk vermek gibi istenilen özellikleri kazandırmak için gerçekleştirilmektedir. Gıdalara kazandırmış olduğu bu özelliklerin yanında gıdalarda olumlu ve olumsuz özellikler meydana gelmektedir. Maillard reaksiyonu sırasında açığa çıkan akrilamid gıda için zararlı olan kanserojen maddelerden biridir. Besin içeriği ve kalitesini olumsuz yönde etkileyen bu reaksiyon ısıl işlem görmüş olan her gıdada meydana gelerek her insan için önemli hale gelmektedir. Gerçekleşen olumsuz özellikler gözlemlendiğinde bu etkiler azaltılmak için çabalansada gıdada istenmeyen ve hoş gözükmeyen etkiler oluştuğu için bu gibi fikirlere ve uygulamalara sıcak bakılmadığı görülmektedir. Maillard reaksiyonu tepkimesinin olumsuz özelliklerinin yanında olumlu özellikleri de yapılan çalışmalar eşliğinde bulunmuştur. Bu çalışmada gıdalarda önemli bir yeri olan Maillard reaksiyonunun önemi işlenmiş, kanserojen madde olan akrilamid hakkında bilgi verilmiş ve reaksiyon gıdalarının beslenmemizdeki yerleri ile sağlımıza etkilerinden bahsedilmiştir.
Anahtar Kelimeler: Maillard Reaksiyonu, İşlenmiş Gıdalar, Akrilamid

1. Introduction

Maillard Reaction, one of the most important reactions in browning reactions occurring in foods, was discovered after the French scientist C. Maillard heated the solution of glucose and lysine together and browning. (Eskin, 1990). The Maillard reaction, which occurs mostly in heat-treated or stored foods, is carried out in foods to give taste, smell, colour and aroma. After this change in foods, it also contributes to the flavour of foods such as beer, chips, bread. In addition to this efficiency in foods, Maillard reaction affects the nutritional content of foods negatively and

positively. (Fayle & Gerrard, 2002). In this study, the positive and negative effects of the Maillard reaction, which occurs in foods that are frequently included in the diet of people, are emphasised, and information about the Maillard reaction is given by mentioning its place in our diet and its health dimension.

2. Maillard Reaction

The Maillard reaction that occurs in heat-treated foods is a non-enzymatic browning reaction that causes colour, aroma, taste and odour changes in food after heat treatments such as roasting, baking, frying, boiling applied to foods. (Sergen, 2010). The Maillard reaction effect is rarely found in the flavour of heat-treated foods such as cakes, chips, crisps, cereals, bread, etc. Maillard reaction is not a reaction that occurs alone. Maillard reaction, which is a browning reaction such as caramelisation, is a complex reaction that occurs as a result of high heat treatment together with reducing sugars and amino acids. (Boekel, 1998).

The French scientist Louis Camille Maillard (1878-1936) first made the name of the Maillard reaction known in his work on carbohydrates and amino acids. (Ames, 1990). It was first described as a reaction between glucose and glycine (Cerny, 2010).

Maillard reactions cause major physical and chemical changes in heat-treated foods. Changes such as colour, taste and smell occur in foods and these are often appreciated by people (Ames, 1990). Mutagenic and toxic compounds, as well as compounds with antioxidant properties, are formed after the Maillard reaction in the nutritional elements of foods. (Pedreschi, Mery, & Marique, 2008). Hydroxymethylfurfural (HMF) is the most harmful of the toxic mutagenic compounds (Erbaş, 2002).

For the formation of Maillard reactions, factors such as the ratios of reactants, ambient pH, temperature, water activity play a role. (Bozkurt, Göğüş, & Eren, 1998). Water activity, temperature and pH level are decisive factors for the growth of harmful substances (Fayle & Gerrard, 2002).

While colour change occurs in Maillard reaction, the most efficient result is obtained with a pH level of 7 and above. This situation can be explained by the release of melanoids with the reaction of amino groups during the Maillard reaction and the decrease in melanoid development at low pH level. (Mottram, 1994). The reaction rate is generally faster when the pH level is higher and it is known that this rate reaches the highest level when the pH is 10. (Woodruff, et al., 2010). Although it is known that the pH range of 8-10 is the most ideal range, this criterion, which varies from product to product, is known to be less in milk. (Boekel, 1998). In Maillard reactions occurring at low pH levels, deficiency in colour development and deficiency in browning is seen as a normal result. (Ames, 1990).

While the Maillard reaction takes place, the water activity (aw) value of the medium is also very effective. After the studies, it is seen that the Maillard reaction slows down in environments with high and low water content. As a result of low aw, MR slows down with the increase in viscosity, while after high aw, there is a decrease in substrate exchange and the rate of MR (Maillard reaction) slows down again. (Buera, Chirife, Resnik, & Lozano, 1987).

Temperature is another very important factor in Maillard reactions. MR rate approximately doubles with an increase of 10°C in temperature (Hardy, Parmentier, & Fanni, 1999). It is known that the rate of browning proceeds in the same direction with the temperature rate. (Nursten, 2005).

Maillard reaction takes place in 3 stages. In the first stage, one of the reducing sugars; glucose reacts with amino acids. As a result, Amadori occurs (Owen, 1996).

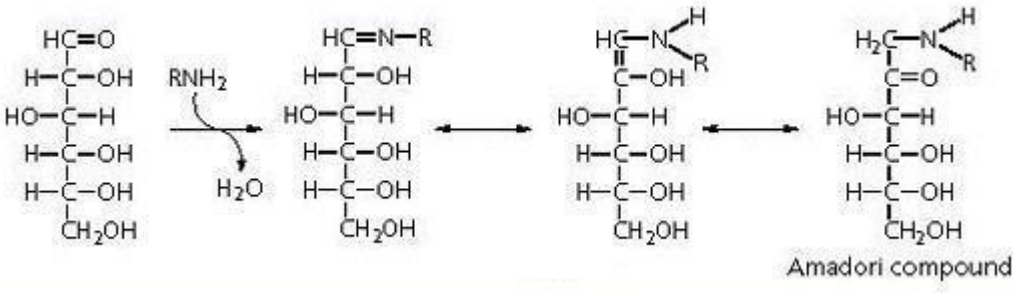

Figure 1: First Phase of the MR of the Reaction of Glucose with an Amino Acid (RNH2), Side **Cluster** of Amino Acid R (Owen, 1996)**.**

In the second stage, hydroxymethylfurfurour (HMF) and furfural are formed by substitution of amino acids. These are important flavour compounds (Owen, 1996). The last stage is the stage where the final colours are formed. It is the stage in which coloured products with a high molecular weight are formed. (Hodge, 1953). In the final stage, brown nitrogenous polymers and copolymers are formed. (del Castillo, Villamiel, & Corzo, 2006).

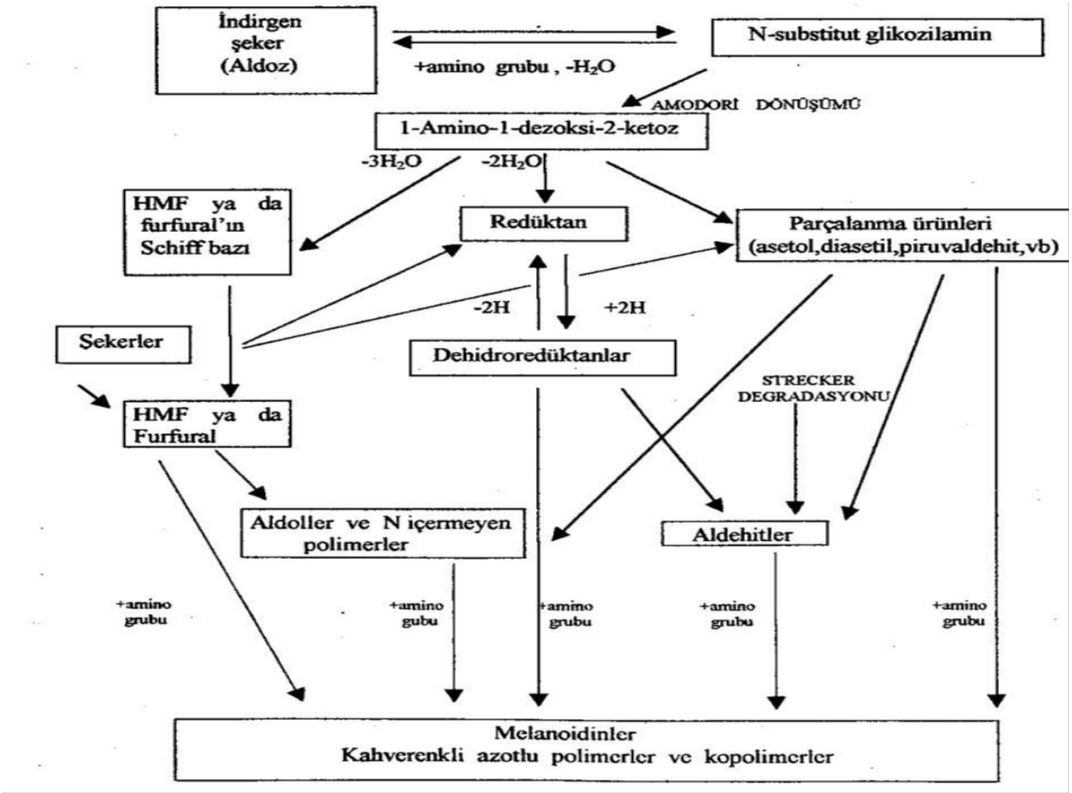

Figure 2: Maillard Reaction (Hodge, 1953; Burdurlu and Karadeniz, 2002).

3. Maillard Reaction Product Acrylamide

In addition to the desired change effects of Maillard reaction such as colour, taste, aroma in foods, it also leads to the growth of carcinogenic substances called acrylamide. When foods are exposed to heat, it can cause acrylamide formation as well as effects such as browning with Maillard reaction. (Friedman, Biological Effects of Maillard Browning Products That May Affect Acrylamide Safety in Food, 2005). The formation of acrylamide can be considered together with the Maillard reaction. The side reaction of Maillard reaction is acrylamide. Carcinogenic acrylamide is known to be present at certain levels in carbohydrates. There have been many studies on what is effective in the reduction or formation of acrylamide in foods, which has important effects on health. Studies have been carried out to reduce acrylamide on the outer surface of crusted products such as bread and chips with the addition of amino acids and it has been suggested that this is effective (Simons, et al., 2009). As a result of the reduction of acrylamide, the changes that will occur in foods should be waived. Reduction of acrylamide will result in loss of taste and colour in foods (Ehling & Shibamoto, 2005).

Acrylamide is also found in carbohydrates, foods such as potatoes, toast, biscuits, bread. In addition to these foods, it is also found in soya beans, nuts and peanut butter, roasted food products (Burdurlu & Karadeniz).

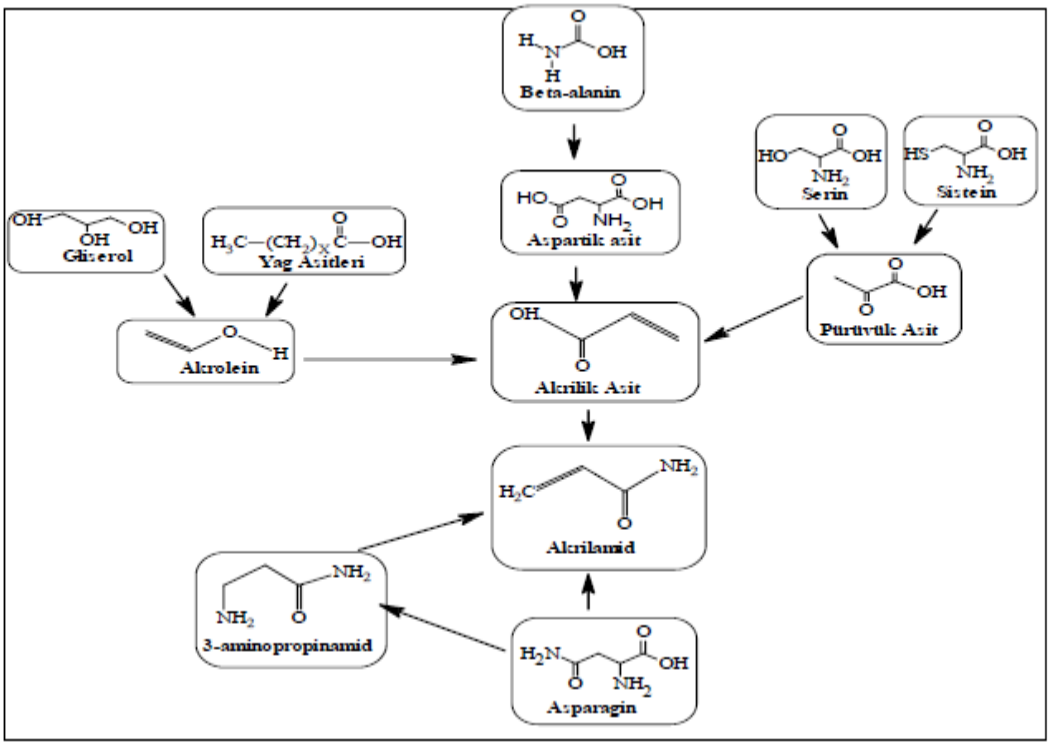

Figure 3: Occurrence of acrylamide in foods (Nizamlıoğlu & Nas, 2019).

4. Processed Foods in which Maillard Reactions Occur

It is known that Maillard reaction occurs as a result of heat treatment applied to foods and Maillard reaction effects are seen in the products**.** Maillard Reaction Products (MRPs) are the products that give foods factors such as colour and special aroma and cause changes in their chemistry. (Mlotkiewicz, 1998). While room temperature is sufficient for Maillard reactions to occur, 120-150°C heat is required for caramelisation, which is similar to Maillard reaction. While the initiation of the reaction in foods proceeds slowly during the shelf life, the reaction occurs rapidly after heat treatment and forms Maillard Reaction Products. Factors such as water activity, pH and temperature change the composition of the foods formed (Yildiz, et al., 2010).

Changes such as odour, aroma, colour and taste, changes in nutritional value and the formation of toxic components in foods subjected to heat treatment are factors affecting the quality of foods. (Anese, Parpinel, Franceschi, Nicoli, & Lerici, 1997). Such factors play a role in the durability and safety of food (Shibamoto & Lee, 2002). Maillard reaction is important for every product subjected to heat treatment. It is of decisive importance in the odour and taste of products such as coffee, chips, bread, french fries. The presence of quite a lot of acrylamide (AA) has been detected in such frequently consumed foods (Friedman & Levin, 2008). Many foods such as beer, French fries, corn chips, bread, biscuits, cakes, rice can be given as examples of products in which Maillard reaction occurs. There are foods such as coffee whose taste and aroma are directly affected by roasting. The aroma of coffee is a combination of Maillard reaction and caramelisation (Fayle & Gerrard, 2002).

Different reaction characteristics are observed for each food. Hydroxymethylfurfura (HMF), which occurs as a result of heat treatment and is one of the intermediate reactions, plays a role in affecting the heat treatment strength and quality of the milk to be treated. It is known that Maillard reaction does not cause colour change in drinking milk available in the market. This shows that Maillard reaction does not cause colour change in every product. (Boekel, 1998). In the direction of new studies, it is known that Maillard Reaction Products have antioxidant properties besides their harmful effects. (Yildiz, et al., 2010). It is known that allergenic substances are reduced in milk proteins after a controlled Maillard reaction. (Erkaya & Şengül, 2012).

	Acrylamide Content of Foods		
Food/Products	**Mean**	**Minimum-Maximum**	**Sample Number**
Potato chips	1312	170-2287	38
French fries	537	<50-3500	39
Boiled Potatoes	<30	-	-
Corn Chips	218	34-416	7
Popcorn	500	365-715	3
Corn Flakes	122	35-478	7
Pastries	36	<30-42	2
Baked Products	112	<50-450	19
Pasta	<30	-	-
Biscuit	198	<10-648	16
Baby Biscuit	152	32-613	24
Diabetic Biscuit	270	10-1695	125
Cookie/ Biscuit	300	<30-640	11
Sweet Biscuit	443	<68-1150	15
Salted Biscuit	179	13-224	2
Child Biscuit	106	5-432	130

Bread	38	<10-85	22
Toast Bread	164	41-474	5
Cracker	247	26-587	18
Breakfast Cereals	298	<30-1346	29
Milk Toast	50	<30-162	41
Pita Bread	<10	<10-16	6
Savory Bun	120	<10-441	4
Fish and Seafood	35	30-39	4
Poultry	52	39-64	2
Adana kebab	127	49-250	4
Chopped Meat	57	52-63	3
Doner	65	-	3
Beer	50	<50-70	3
Chocolate Powder	75	<50-100	2
Cocoa	<10	-	3
Coffee Powder	200	170-230	3
Chocolate	75	37-100	5
Roasted Almonds	260	207-313	2
Roasted Hazelnut	128	<10-421	5
Roasted Peanut	66	<10-120	5
Roasted Chickpea	12	<10-33	4
Nut Butter	53	<10-141	4

Table 1: Acrylamide Content of Foods (Michalak, Gujska, & Kuncewicz, 2013) (Cengiz & Gündüz, 2013) (Süvari, 2015) (Ölmez, Tuncay, Özcan, & Demirel, 2008) (Arusoğlu, 2015).

5. The Place of Maillard Reaction Products in Our Nutrition and Their Effects on Health

One of the most important reactions in the application of heat treatment for the preservation and processing of foods is the Maillard reaction. While the Maillard reaction supports the preservation of food in food science, it also affects the food by causing changes such as taste, colour, smell, aroma in food in health and nutrition issues. When viewed through food science, the occurrence of changes in food and the change of nutrient contents after the reaction show both positive and negative properties of the Maillard reaction. (Nursten, 2005). Many studies in the past have emphasised the damages of the Maillard reaction and mentioned the deterioration of the nutrient content with toxic MRUs. (Chau, Lii, & Yen, 1993). The negative effects of the nutritional value of foods, the decrease in vitamins and minerals are among the undesirable negative effects caused by the deterioration of the structure of amino acids. The formation of toxic compounds after heat treatment and the deterioration of the immune system are among the known negative effects. (Brownlee, Vlassara, & Cerami, 1984) In addition to the browning effect especially in bakery products after Maillard reactions, digestive problems also occur as a result of the decrease in calorie value in food and the formation of compounds that are not digested in the body. Protein, which is taken from foods and is important for humans, also decreases or its quality is damaged after MR. (Elgun & Ertugay, 2002).

It is also known that acrylamide is found in fried chips and has a negative effect on human health (Pedreschi, Mery, & Marique, 2008). HMF, which occurs as an intermediate reaction during the Maillard reaction, is found in products such as tomato paste, honey, molasses and adversely affects human health. (Poretta, 1991).

Maillard reactions have positive effects as well as negative effects. Producing antioxidants during the reaction is one of the biggest positive effects. It is known that some foods show antioxidant properties after the reaction (Mastrocola, Manzocco, Nicoli, Lerici, & Calligaris, 2001). It is also known that some MRPs have antimutagenic properties and have a favourable effect on the intestinal tract. Studies have suggested that beneficial compounds are present in the first stages of Maillard reactions. Based on this, some of the MRLs can also be referred to as beneficial products and products containing antioxidants. (Chobert, Genot, Haertle, & Chevalier, 2001).

6. Conclusion and Recommendations

Maillard reaction is a complex reaction that occurs with heat treatment of foods. The Maillard reaction, which gives foods taste, smell, aroma, aroma, colour change and supports the preservation of foods for a long time, also gives foods negative properties as well as these properties. As a result of the literature review, it has been observed that Maillard reaction products are found in many foods in the diet of people. The negative effects of the Maillard reaction have been emphasised and many studies have been organised on them. As a result of the literature review, it has been observed that some of the studies also have positive properties of the Maillard reaction and these are transferred to foods. It was observed that Maillard reaction effects were kept at optimum level. It is thought that the negative effects of Maillard reaction should be tried to be minimised with the methods used and researches should be carried out in this direction.

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