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Formation of taste and aroma compounds by Maillard reaction during processing of food products

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Abstract.

The Maillard reaction plays an especially important role in the thermal processing of food products. During the heat treatment of vegetable and animal products, glucose and fructose, formed as a result of sucrose hydrolysis, are mainly involved in the sugar-amine reaction as a carbohydrate component, while free amino acids and proteins are used as an amino component. The compounds formed during the Maillard reaction determine the aroma and taste of the thermally treated product [1]. Recently, it was found that the Maillard reaction occurs also in the body [2]. Excess glucose in the body is assumed to bind to proteins through the Maillard reaction, leading to early aging, atherosclerosis, diabetes, and other diseases [3]. The smell and taste of products are due to the compounds resulting from the Maillard reaction in food processing. In products of plant, animal, or microbial origin, all conditions are present (the content of sugars, amino acids, proteins, water, acidic, neutral, or basic medium) promoting the processes involved in the Maillard reaction. and different types of heat treatment as baking, roasting, boiling, and drying cause these processes at different intensities.

Key Words: Maillard reaction, amino acid, aromatic compounds, flavor compounds

Introduction

The Maillard reaction plays an especially important role in the thermal processing of food products. During the heat treatment of vegetable and animal products, glucose and fructose, formed as a result of sucrose hydrolysis, are mainly involved in the sugar-amine reaction as a carbohydrate component, while free amino acids and proteins are used as an amino component. The compounds formed during the Maillard reaction determine the aroma and taste of the thermally treated product [1].

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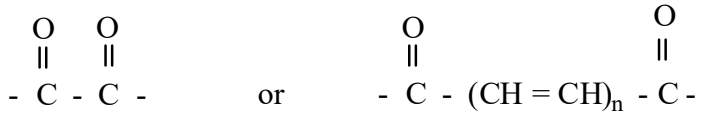
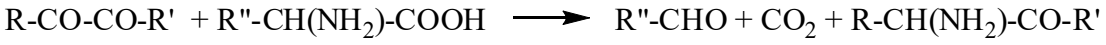
The smell and taste of products are due to the compounds resulting from the Maillard reaction in food processing (Scheme 1). In products of plant, animal, or microbial origin, all conditions are present (the content of sugars, amino acids, proteins, water, acidic, neutral, or basic medium) promoting the processes involved in the Maillard reaction. and different types of heat treatment as baking, roasting, boiling, and drying cause these processes at different intensities.

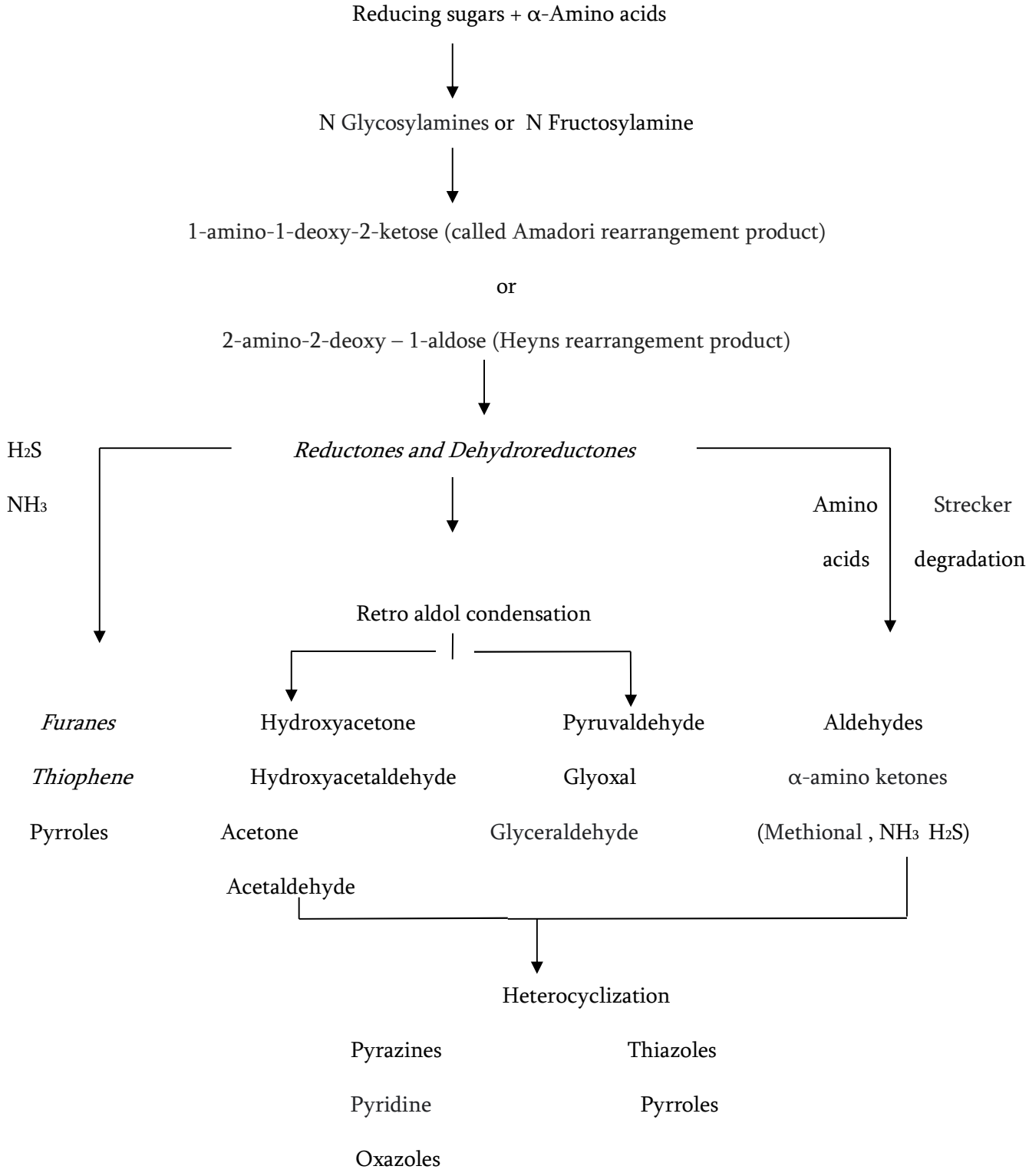
During the processing of food products, aromatic compounds are mainly formed in the second stage of the Maillard reaction [4]. First of all, the oxidative degradation of α-amino acids by dicarbonyl compounds is particularly important. During this process formed aldehydes contain one carbon atom less than the original amino acid. Such an oxidation is named Strecker degradation. A necessary condition for this reaction is that he amino group must be in the α-position, and the dicarbonyl compound must contain the following groups:



The reaction is expressed by the equation:



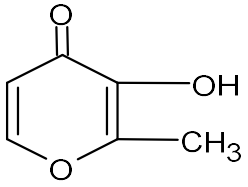
If the hydrogen atom at the α-carbon of the amino acid is substituted, than a ketone is obtained.



Scheme 1. Formation of aromatic and flavor compounds as a result of Maillard reaction

Table 1 shows the aroma obtained by heating some mixtures containing α-amino acid and glucose in an equimolar ratio (1:1 [4]. The author of this research notes that the odor of the reaction mixture is quite different from that of the corresponding pure aldehyde. The same mixture produces different aromas at different temperatures, indicating that the aldehydes produced by Strecker degradation react with other compounds in the melanoid medium to form new aroma compounds.

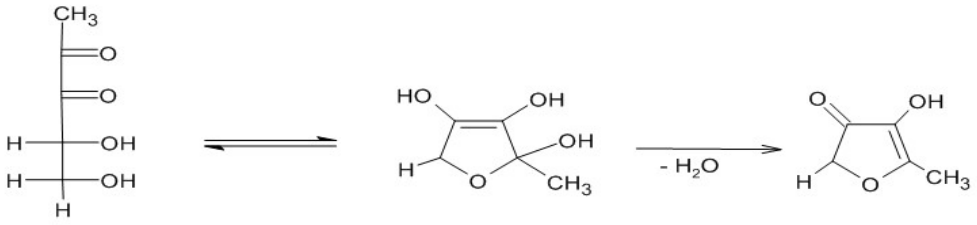
Such products of sugar-amino acid reaction are 2-furaldehyde, which has the flavor of baked bread and maltol, having a mild, caramel-like flavor. Initially, maltol was isolated from autoclaving products of glycine-maltose and glycine-lactose aqueous solutions by Patton with a yield of 0.2% [5]. Further investigations have revealed that in the Maillard reaction maltol is always formed from 4-oxygen-substituted glucose, such as maltose, lactose, cellobiose, malto-oligosaccharides [3].



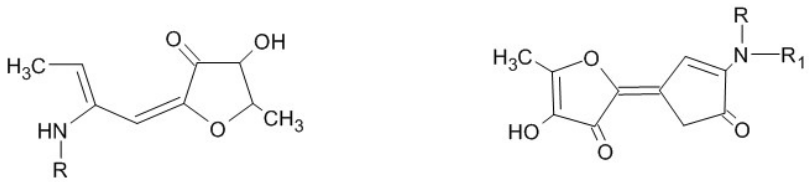
Maltol

The Maillard reaction of a mixture of glucose and α-alanine yielded the inner salt of N-(1-carboxyethyl)-6-(hydroxymethyl)-pyridinium-3-ol. It has no taste but is a mild enhancer of sweet taste, and it is a melanoidin-derivative non-volatile sweetness enhancer [5]. During the Strecker degradation, an especially important role in the formation of aromatic components together with aldehydes play such compounds as 3-deoxyhexozones, which contain α-dicarbon grouping on C1 and C2 carbon atoms, and methyl-α-dicarbon intermediate products, having such grouping on C2 and C3 carbon atoms. 3-deoxyhexozones, Both types of α-dicarboxylic intermediates can produce flavor compounds, for example, furaldehydes from 3-deoxyhexozones, and acetaldehyde, pyruvaldehyde, diacetyl, and acetic acid by cleavage of methyl-α-dicarboxylic intermediates and their dehydration products.

It should be noted that these products are produced from sugars also without amino compounds. In particular, as a result of 1,2-enolization of sugars in the process of caramelization. At a high temperature, in a strong acid or strong base medium, the hydroxyl group located at the C3 and C1 carbon atoms are eliminated. Condensation with amino compounds, however, allows such enolisation and elimination to occur in a neutral region and at lower temperatures [6]. Important aroma-active compounds furanoses are formed from 1-deoxy-ozone:



Pentoses further react with amines to form orange dyes, which determine the color of the food



product:

Compounds formed from 3-deoxy-ozones contain fragments of pyrrole, pyridine, and formylpyrrole. As a result of the condensation of two amino ketones, various pyrazine derivatives can be formed, which are also aroma-active compounds:

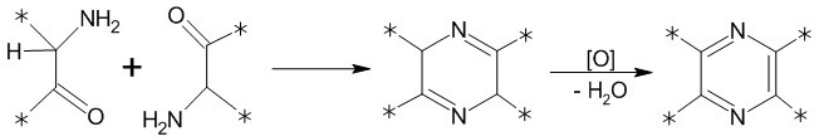
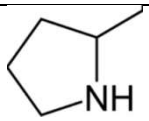
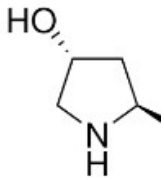
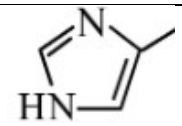


Table 1. Aroma obtained by heating some mixtures containing α-amino acid and glucose (1:1) [7]

α-amino acid	R-CH(NH2)COOH R=	Aldehyde R-CHO	Flavor	
			100 °C	180°C
Glycine	H-	Formaldehyde	Caramel	Burnt sugar
α - Alanine	CH_3-	Acetaldehyde	Caramel	Burnt sugar
α-Aminobutyric acid	CH_3- CH_2-	Propionaldehyde	Caramel	Burnt sugar
Valine	$(CH_3)_2$- CH-	2-methylpropanal	Rye bread	Intense chocolate
Leucine	$(CH_3)_2$- CH- CH_2-	Isovaleraldehyde	Fruit	Burnt cheese
Isoleucine	CH_3- CH_2- CH- (CH_3)-	2-methylbutanal	Mold, fruit	Burnt cheese
Serine	HO- CH_2-	Glycoaldehyde	Maple syrup	
Threonine	CH_3- CHOH-	Lactaldehyde	Chocolate	Burning smell
Methionine	CH_3- S- CH_2- CH_2-	Methional	Potatoes	Potatoes
Phenylglycine	C_6H_5-	Benzaldehyde	Bitter almonds	
Phenylalanine	C_6H_5 - CH_2-	α - Tolualdehyde	Smell of violet, rose	smell of Violet, rose, lilac
Tyrosine	HO- C_6H_4 - CH_2-		Caramel	
Proline			of burnt protein	pleasant, of baked

Hydroxyproline			Potatoes	
Histidine			Does not have	Cornpone
Arginine	$H_2N-C=NH-NH-(CH_2)_2-$		Weak, of butter	
Lysine-HCl	$H_2N-(CH_2)_4-$		Does not have	Similar to bread
Aspartic acid	$HOOC-CH_2-$		Ice-caramel	Caramel
Glutamic acid	$HOOC-CH_2-CH_2-$		Caramel	Burnt sugar
Glutamine	$H_2N-CO-CH_2-CH_2-$		Pleasant, of chocolate	Iris
Cysteine-HCl	$HS-CH_2-$		Sulfide, meat	
Cystine	$-CH_2-S-S-CH_2-$		Sulfide, burned skin	

According to the data many representatives of aroma and taste compounds, including heterocyclic compounds, are formed as a result of the thermal degradation of melanoidin products at 100^0C and higher temperatures. For example, during heat treatment of melanoidin produced on the base of glucose-glycine (120, 150, and 180 ^{0}C), pyrazines made up 54-79% of the total amount of volatile compounds. Pyrroles, ketones, furans, oxazoles, and pyridines were also identified among the volatile products. The reaction pH and pressure significantly affect the direction and intensity of the thermal degradation process [8-10]. Through the thermal degradation of this type of melanoidin's (100-300^0C), the maximum formation of furans, pyrroles, pyrazines, and carbonyl compounds was observed at 200-220^0C, and of pyridines and oxazoles at higher temperatures [11].

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საკვები პროდუქტების გადამუშავების დროს საგემოვნო და სურნელოვანი ნაერთების წარმოქმნა მაილარდის რეაქციით

ნონა ბოლქვაძე[1] , სოფიო გვიდანი [2], რუსუდან ურიდია [3], ნანა წეროძე [3], ნინო ქავთარაძე [3], ლეილა ტატიაშვილი [3], ნინო ქარქაშაძე [3]

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მაილარდის რეაქცია განსაკუთრებით მნიშვნელოვან როლს ასრულებს კვების პროდუქტების თერმოდამუშავების პროცესში. მცენარეული და ცხოველური პროდუქტების თერმოდამუშავებისას შაქარ-ამინურ რეაქციაში ნახშირწყლოვანი კომპონენტის სახით ძირითადად თავისუფალი ან საქაროზას ჰიდროლიზის შედეგად წარმოქმნილი გლუკოზა და ფრუქტოზა, ხოლო ამინური კომპონენტის სახით თავისუფალი ამინომჟავები და ცილები მონაწილეობს. მაილარდის რეაქციის პროცესში წარმოქმნილი ნაერთები ფაქტობრივად განსაზღვრავს თერმულად დამუშავებული პროდუქტის არომატსა და გემოს [1]

ბოლო დროს დადგინდა, რომ მაილარდის რეაქცია ორგანიზმშიც მიმდინარეობს [2] როგორც ვარაუდობენ ორგანიზმში ჭარბი გლუკოზა მაილარდის რეაქციის საშუალებით უერთდება ცილებს, რაც იწვევს ადრეულ სიბერეს, ათეროსკლეროზს, დიაბეტსა დასხვა დაავადებებს [3]

საკვები პროდუქტების გადამუშავების პროცესში მაილარდის რეაქციის შედეგად წარმოქმნილი ნაერთებითაა განპირობებული პროდუქტების სურნელი და გემო. მცენარეული, ცხოველური ან მიკრობული წარმოშობის პროდუქტებში ყველა პირობა არსებობს (შაქრების, ამინომჟავების, ცილების, წყლის შემცველობა, მჟავე, ნეიტრალური ან ფუძე არე) იმ პროცესების წარმათვისათვის, რომლებსაც მაილარდის რეაქცია მოიცავს, ხოლო თერმოდამუშავების ისეთი სახეები, როგორიცაა ცხობა, შეწვა, ხარშვა, შრობა სხვადასხვა ინტენსივობით წარმართავს ამ პროცესებს.

საკვანძო სიტყვები: მაილარდის რეაქცია, ამინომჟავები, სურნელოვანი ნაერთები, საგემოვნო ნაერთები