Agriculture College – Wasit University

Dijlah Journal of Agricultural Sciences

ISSN 2790 – 5985

eISSN 2790 – 5993

Dijlah J. Agric. Sci.، 5(1):112-121, 2026

Estimating the quantity of Maillard reaction products in baby biscuits

Rawaa Q. AL-Mayahi, Mohammed Jameel Mohammed and Ahmed I.A. ALnazzal

Department of food sciences, College of Agriculture, Tikrit University, Iraq

Corresponding author: rawaa.q.q009@st.su.edu.iq

Abstract:

The Maillard reaction is a non-enzymatic reaction that occurs between reducing sugars and free amines in food products. This reaction alters sensory properties and leads to adverse health consequences due to the production of mutagenic compounds and the resulting lysine deficiency. Numerous attempts have been made to control the Maillard reaction in recent decades. Estimating Maillard reaction products (MRPs) in children's biscuits involves quantifying specific compounds, such as furosene and HMF, using analytical techniques like chromatography. Key factors influencing MRP levels include processing conditions (temperature, humidity and pH), storage duration and conditions, and ingredient composition (fat and protein content). The presence and accumulation of these products, particularly during storage, are crucial for assessing potential health effects on children.

Keywords: *Maillard reaction, baby biscuits, HMF, furosene.*

Received:22/11/2025 **Accepted:21/12/2025** **Published:11/1/2026**

تقديــر كمية نواتـج تفاعلات ميــلارد في بسكويت الاطفال

رواء المياحي، د. محمد جمال محمد و د. احمد النزال

قسم علوم الاغذية، كلية الزراعة، جامعة تكريت، العراق

الخلاصة

تفاعل ميلارد هو تفاعل غير إنزيمي يحدث بين السكر المختزل والأمين الحر في المنتجات الغذائية يُغير هذا التفاعل الخصائص الحسية ويؤدي إلى عواقب صحية سلبية بسبب إنتاج مركبات مُطفرة، كما يُؤدي إلى عدم توفر اللايسين. بُذلت محاولات عديدة للسيطرة على تفاعل ميلارد في العقود الماضية يتضمن تقدير نواتج تفاعل ميلارد (MRPs) في بسكويت الأطفال تحديد كميات مركبات محددة، مثل الفوروسين وHMF باستخدام تقنيات تحليلية مثل الكروماتوغرافيا. تشمل العوامل الرئيسية المؤثرة على مستويات نواتج تفاعل ميلارد ظروف المعالجة (مثل الحرارة، والرطوبة، ودرجة الحموضة)، ومدة وظروف التخزين، وتركيب المكونات (مثل محتوى الدهون والبروتين). يُعدّ وجود هذه المنتجات وزيادتها، وخاصةً أثناء التخزين، أمرًا بالغ الأهمية لتقييم الآثار الصحية المحتملة على الاطفال.

الكلمات المفتاحية: *فستق الحقل، محسنات التربة، مثبطات النتح، الاستهلاك المائي الفعلي، معامل المحصول، الري بالتنقيط.*

1. Introduction

In 1912, the French chemist Louis Camille Maillard discovered the phenomenon of non-enzymatic browning when he heated a solution containing a sugar and an amino acid. The Maillard reaction does not only produce color: reactions between amino acids, peptides, or proteins and reducing sugars also produce a wide range of flavor and aroma compounds. This reaction affects the quality and nutritional value of heated foods. Importantly, infant cereals must be processed to improve their dispersibility in liquids and digestibility, as infants aged 3 to 4 months have a limited ability to digest starch. Processing infant cereals includes stages of successive roasting, hydrolysis using the enzyme alpha-amylase (starch breakdown), and drying. Heat treatments used in food production and processing, such as baking, drum drying, frying, grilling, or storage at relative humidity between 30% and 70%, cause a basic reaction that inhibits the absorption of lysine by the body (1). The term “Maillard reaction” refers to a complex series of reactions between the free amino acids of proteins and the reactive carbonyl groups of reducing sugars such as glucose, which leads to the formation of melanoidins, giving food a distinctive flavor and a distinctive brown color. This reaction initially forms glycosylamines, which are later rearranged into ketosamines, and undergo further reactions to produce various flavor compounds and brown nitrogen polymers, ultimately leading to the distinctive brown color of food (2).

The first stage of the reaction, known as the early Maillard reaction, involves a series of reactions including initial condensation (by the addition of a nucleophile) and rearrangement and fractionation of reducing sugars and amino acids (3). The reaction begins with the condensation of the carbonyl group of the reducing sugar with the amino group of the nucleophilic amino acid to form a Schiff base or the amadori rearrangement product (4). These initial products are reversible and can undergo further transformations. The Amadori rearrangement is a crucial step in the mechanism of the early Maillard reaction, where the carbonyl group migrates from the C1 position of the reducing sugar to the C2 position, resulting in the formation of a more stable ketoamine compound (5).

The Amadori compound readily transforms into three different structures, and the next step varies depending on the Amadori compound. The amino acid can be removed to produce reactive compounds that eventually decompose into the two important flavor components: furfural and hydroxymethylfurfural (HMF). The second step is the Amadori rearrangement, which is the starting point for the main browning reactions. After the Amadori rearrangement, three different main pathways can be distinguished: dehydration reactions, cleavage with the production of diacetyl, and the hydrolysis of pyrovaldehyde with amino acids that condense into aldol. These three main pathways lead to complex mixtures that include flavor compounds and high molecular weight brown pigments called melanoids (7). A comparative study of changes in available lysine content and protein nutritional quality during the industrial production of food and standard biscuits found that the lysine content in all types of biscuits decreased significantly during baking by 27% to 47%, and that the amount of lysine lost increased with increasing temperature and baking time. Therefore, the aim of study was to estimate the quantity of Maillard reaction products in baby biscuits.

2. Materials and Methods

Samples of biscuits collected from children aged 6 months to 3 years were studied. These biscuits were collected between February 2024 and March 2024 from various retail outlets and supermarkets in Salah al-Din, Iraq. The biscuits were manufactured in Egypt, Turkey, Belgium, Malaysia, and the UK. Ten different biscuit brands were collected from each country of origin, with three replicates. Samples were taken from the most popular brands consumed by different income groups and age groups, including children. The biscuit samples were thoroughly ground before analysis. Each sample was divided into three parts, and each part was analyzed separately.

Estimation of Maillard reaction products in biscuits

Maillard reaction products (MRBs) in commercial infant formulas were evaluated to assess the heat damage these foods undergo during manufacturing (roasting and drying). They also provide information on the amount of lysine modified or blocked by heat, and therefore the amount of loss in nutritional value. Furosene (2-furoylmethyl-ε-lysine), hydroxymethylfurfural (HMF), CML, and lactulose are among the most common Maillard reaction products used to estimate the intensity of heat treatments and are referred to as chemical heat indicators (7). The use of furosene in infant cereals is a hallmark of recent research in food science. These compounds, which may be desirable in some cases and a significant challenge in others, are linked to two major problems in food and beverage production, marketing, and storage (10, 11):

1- Loss of nutritional value resulting from Maillard reactions under extreme heat treatment or prolonged storage at high temperatures.

2- The health risk posed by the presence of one or more MRBs in food, which may not be inherently dangerous, but whose presence in the food composition contributes to the formation of molecules harmful to health. The early stages of the Maillard reaction can be assessed by determining furosine (e-N-furoylmethyl L-lysine), an amino acid formed by the acid hydrolysis of fructosyl-lysine, ectulosyl-lysine, and maltosyl-lysine from lysine with glucose, lactose, and maltose, respectively. This amino acid has been used to measure the early stages of the Maillard reaction in food products (8). Furosine determination has been used to monitor non-enzymatic browning in cakes and to monitor pasta processing. The first (9) to discover this compound named it furosine and identified other MRBs, but these are less important in determining the nutritional value of heat-treated protein foods than furosine. Furosine does not exist free in food; rather, it is produced by the acid hydrolysis of MRBs, with 30-40% of these compounds being converted to furosine (10). The chemical composition of furosene is C12H18N2O4, its molecular weight is 254.286 g/mol, and its melting point is 97.5 °C.

For the determination of hydroxymethylfurfural (HMF), 5-hydroxymethyl-2-furaldehyde, which is a product of the thermal decomposition of sugars, there are two main methods for its formation. First, HMF is formed during the Maillard reaction, and second, during the thermal drying of sugars under acidic conditions. Its chemical formula is $C_6H_6O_3$.5-(hydroxymethyl)furan-2-carbaldehyde, or 5-hydroxymethyl-2-furaldehyde, commonly known as HMF. It is a cyclic furan (FURAN) molecule consisting of an unsaturated five-membered ring containing an oxygen atom. HMF has a molecular weight of 126.111 g/mol and a melting point of 31.5 °C. It is a crystalline solid with an odor similar to chamomile flowers and a taste resembling caramel or butter. It is soluble in water and organic solvents (12).

HMF is considered a newly formed contaminant that arises in foods during heat treatment, especially under acidic conditions (15). HMF can be obtained from the degradation of L-ascorbic acid and the dehydration of fructose and glucose hexones (16). Research into this compound has continued since the mid-20th century and remains a focus of interest. One reason for this interest is the potential toxicity of HMF, particularly its metabolites, most notably 5-Sulfoxymethylfurfural (SMF). Although the toxicity of this compound to humans is not definitively established, some studies conducted on laboratory animals, cell cultures, and bacteria have indicated that HMF can be an eye and respiratory irritant, hepatotoxic, and nephrotoxic, and may cause cancerous tumors. It should be noted that the maximum dose used on laboratory animals without causing adverse effects due to toxicity was approximately 80-100 mg/kg/day (17).

Furosine Quantification

The furosine content in infant cereals was used to assess the heat damage caused by these cereals. During food processing (roasting, starch analysis, and drying), furosemide was measured in samples of dry infant foods, such as biscuits, intended for children over two years old, in the laboratories of the Ministry of Science and Technology, as mentioned (18). The analysis, using HPLC, involved taking 10 g of a finely ground and homogenized sample, placing it in a 100 ml round-bottom flask, adding 50 ml of deionized water, then adding 1 ml of 15% substance A and 1 ml of 30% substance B.

The volume in the round-bottom flask was then brought to 100 ml using deionized water. The solution was left to concentrate for half an hour, then filtered using 0.45 µm filter paper and refiltered through fine filters. Two solutions were used as the mobile phase: Solution A, consisting of dilute acetic acid (prepared by mixing 4 ml of concentrated acid with 1000 ml of distilled water), and Solution B, consisting of potassium chloride solution prepared by dissolving 3 g of potassium chloride in 1000 mL of Solution A was used in an ODS column (250 × 4.6 mm ID) and detected using a UV detector at a wavelength of 280 nm. Solutions A and B were used in a 50/50 ratio as the mobile phase at a flow rate of 1.2 mL/min. 20 µL of the digested and prepared sample was injected and passed through a 0.22 mm microfilter. The sample was injected into an HPLC apparatus, and using a standard curve with known concentration, the furosene concentrations in the samples were estimated.

Determination of HMF

The hydroxymethylfurfural (HMF) content of biscuit samples was determined in the laboratories of the Ministry of Science and Technology following the method described in reference (19), which included several steps, among them: weighing 3 g of the biscuit sample after grinding and homogenization, adding 50 mL of deionized water to it in a 100 mL volumetric flask, and transferring it to an ultrasonic water bath for 15 minutes. Add 1 ml of 15% potassium ferrocyanide solution and 1 ml of 20% zinc sulfate solution and complete the volume to 100 ml with deionized water. Take the extract from the biscuit samples to estimate the hydroxymethylfurfural content using a high-performance liquid chromatography (HPLC) device (Dionix, Germany) at a wavelength of 285. The samples were manually injected with a volume of 25 microliters. The separation column was an XSELECTT TTMTM CSHTMTM 130 C18 with a length of 4.6 × 100. The moving length was a mixture of water/acetone triacetate in a ratio of 10:90.

3. Results and Discussion

The mean values for furosine content in the biscuit samples used in the study from different origins: Egypt, Turkey, Britain, Belgium, and Malaysia. The results of the statistical analysis indicated significant differences between treatments ($p \leq 0.05$) including T5, T6, T7, T8, T9, T1, T2, and T3 from different origins. However, for samples T4 and T10, the results did not indicate significant differences between the mean values for furosine content (Table 1). Figure (1) shows the standard HPLC plot for furosine content. Our results are consistent with those of (20), which indicated that furan levels ranged between 1.4 and 90 micrograms/kg in 15 types of baby food from the Japanese market. Recently, the US Food and Drug Administration reported furan levels in ready-to-eat baby foods from the USA ranging from 2.5 to 112 µg/kg (21). This study was consistent with our findings, as the highest furan content was found in the Malaysian-origin sample (T5 9.9500 ± 0.0200 µg/kg). Differences between biscuit types, toasted biscuits, biscuits baked at higher temperatures, and the use of oils, sugar, chocolate, etc., can all alter the furan content. This study also demonstrates that ingredients such as sugar and fat content, and baking conditions (temperature, time, oven ventilation) affect the concentration of furan derivatives in biscuits (22).

Table (1) the furosene content (µg/kg) in samples of Egyptian, Turkish, British, Belgian and Malaysian biscuits

Origin	Biscuits	Retention Time (min)	Area	Concentration (µg/kg)
Egyptian	T1	5.312	470729	0.0470±0.0011
Turkish	T2	5.253	13513889	1.3500 ±0.0200
	T3	5.242	7421188	0.7410±08 0.00
	T6	5.441	28837813	2.8820 ±0.0010
	T8	5.439	154701	0.0150 ±0.0028
	T9	5.236	3277114	0.3270 ±0.0007
	T10	5.590	227034	0. 0220±0.0001
British	T4	5.223	314134	0.0310 ±0.0012
Malaysian	T5	5.447	99533960	9.9500 ±0.020
Belgian	T7	5.212	4022135	0.4020 ±0.0007

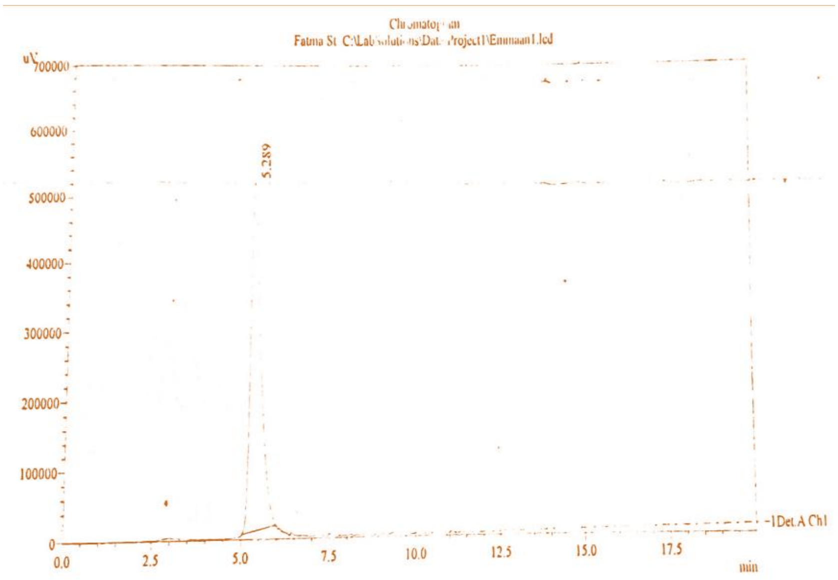

Figure (1) Standard HPLC profile for furose

Figure (1) shows a standard profile for hydroxymethylfurfural. Table (1-2) shows the results for the hydroxymethylfurfural content of the used infant food samples, specifically biscuits. The highest hydroxymethylfurfural content was found in biscuit samples T4 and T7 from various origins, including Britain and Belgium, at (0.1490 and 0.1470) mg/kg, respectively. For the Turkish-origin samples T2, T3, T6, T8, T9, and T10, the average values of their HMF content ranged from (0.0305 ± 0.0003, 0.0036 ± 0.0004, 0.0083 ± 0.0006, 0.0297 ± 0.0099, and 0.0450 ± 0.0450), respectively. The HMF content of the Egyptian samples (T1) was 0.0004, 0.0009 ± 0.0008 mg/kg.

The HMF content of the sample from Malaysia was 0.0104 ± 0.0002 mg/kg. Statistical analysis showed no significant differences between samples (T3, T5, T10), while the remaining samples showed significant differences ($p \leq 0.05$) in their HMF content. The difference in methylfurfural content between the samples is attributed to the type of sweeteners used in the biscuit recipe. Some samples used invert sugar syrup compared to the sucrose used in other biscuits. This study agrees with the findings of Yoshida et al. (23) that HMF content increases rapidly in the presence of Glucose and fructose are the sugars produced from the breakdown of sucrose. Ha et al. (24) Mentioned that the increase in HMF content depends on the water activity and the temperature used in the baking process (200, 250, 300°C) and the presence of sugars (fructose, glucose, and sucrose). Nguyen et al. (25) indicated that the amount of HMF is 100-10 times higher (167.4-1100.1 mg/kg) when using high temperatures, which is less than the content of hydroxymethylfurfural when baked at 200°C (39.6-9.9 mg/kg).

Jandlova et al. (26) The temperatures used in baking, heat treatment time, and ingredients used in producing the children's biscuit samples in our study depend on the formation of the HMF compound. It was also noted that the distribution of the HMF compound within the biscuit varies according to the microbial load used in the baking process. Therefore, using new treatment techniques is important to reduce the production of harmful components or compounds in the final product (27). Furthermore, the variation in the increase or decrease in HMF content is directly affected by the type of heat treatment used in the manufacturing process. Additionally, significant changes in the dough composition, which are not permitted or authorized by manufacturers, can contribute to this variation (28). These results are consistent with the findings of their study on the HMF content of French-origin biscuit samples, where the HMF content ranged from 0.5 to 78.6 mg/kg (29). However, these results did not agree with the findings of (30), which indicated that the HMF content in the biscuits ranged 82.78-1.65 mg/kg.

Table (2) the HMF content (µg/kg) in samples of Egyptian, Turkish, British, Belgian and Malaysian biscuits

Origin	Biscuits	Retention Time (min)	Area	Concentration (mg/kg)
Egyptian	T1	5.972	1230094	0.1220 ±0.0003
Turkish	T2	5.881	305732	0.305 ±0.0003
	T3	5.200	366687	0.0036 ±0.0004
	T6	5.668	83883	0.0083 ±0.0006
	T8	5.797	297946	0.0297 ±0.009
	T9	5.051	453882	0.0450 ± 0.0004
	T10	5.195	9172	0.0009 ±0.0008
British	T4	5.134	1497803	0.1490 ±0.0006
Malaysian	T5	5.617	104511	0.104 ±0.0002
Belgian	T7	5.025	1476200	0.1470 ±0.0100

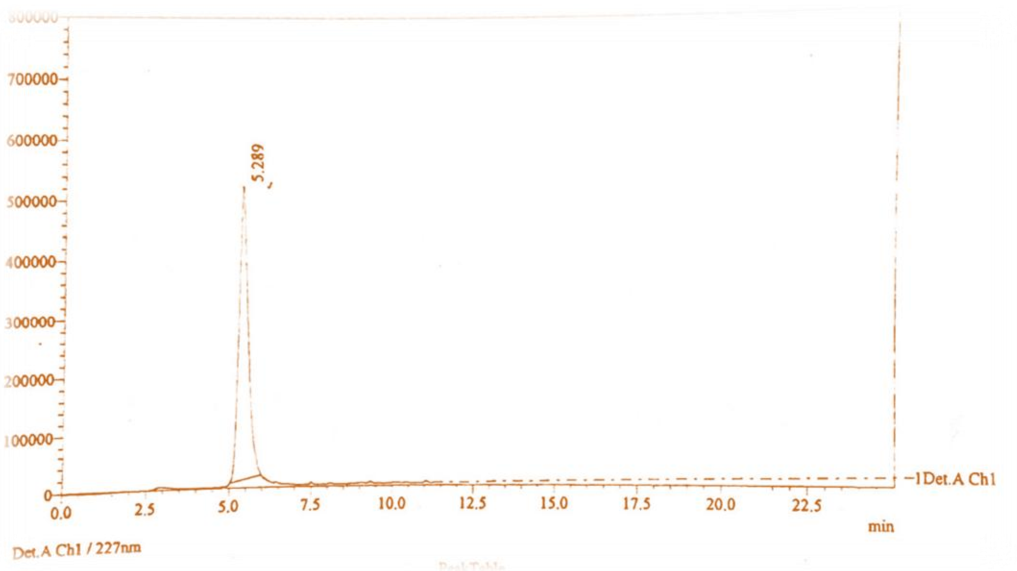

Figure (2) the standard HPLC profile of hydroxymethylfurfural

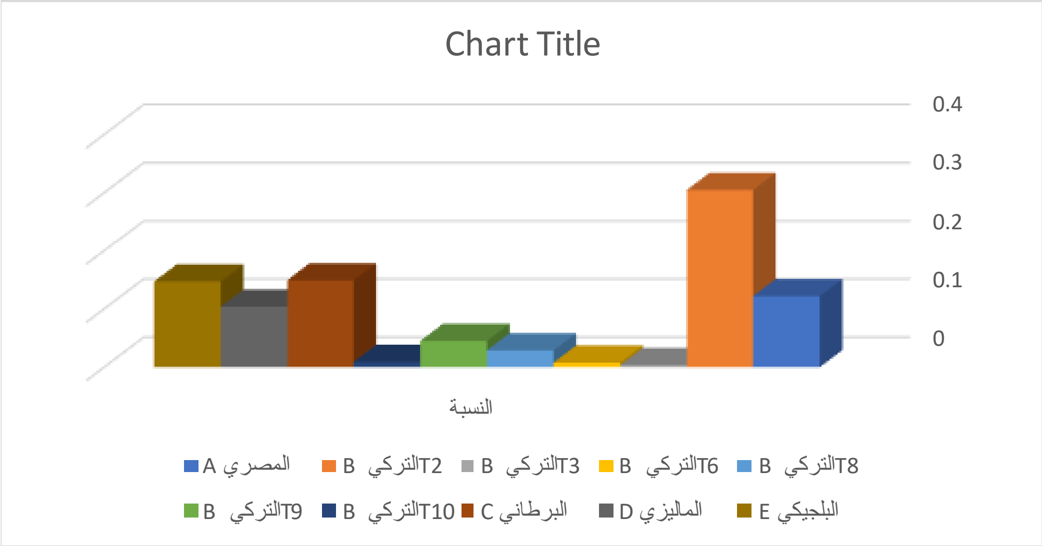

Figure (3) the HMF content of biscuit samples for all biscuit samples used in the study from different origins.

Conclusions

The Maillard reaction is a complex chemical reaction that affects the flavor, color, and texture of many foods. Several factors influence the reaction, including temperature, time, water activity, pH, and the presence of amino acids and reducing sugars. This reaction has both advantages and disadvantages in the food industry, and its nutritional effects are complex and vary depending on the food's composition and intensity. The Maillard reaction is also important in the fermentation, pharmaceutical, and cosmetics sectors. Further research is needed to better understand the Maillard reaction's impact on health and to develop techniques to reduce the formation of hazardous chemicals during food preparation and cooking.

References

1- Erbersdobler, H. F., and Faist, V. 2001. Metabolic transit of Amadori products. Nahrung, 45: 177-81.

2- Alais, C., and Linden G. 1991. Food Biochemistry. Ellis Harwood: Chichester. Pp 130-147

3- Peng, H.; Gao, Y.; Zeng, C.; Hua, R.; Guo, Y.; Wang, Y.; Wang, Z. Effects of Maillard Reaction and Its Product AGEs on Aging and Age-Related Diseases. Food Sci. Hum. Wellness 2024, 13, 1118–1134

4- Visvanathan, R.; Krishnakumar, T. Acrylamide in Food Products: A Review. J. Food Process Technol. 2014, 5, 344

5- Luo,Y.; Li, S.; Ho, C.-T. Key Aspects of Amadori Rearrangement Products as Future Food Additives. Molecules 2021, 26, 4314.

6- Shumilina, J.; Kusnetsova, A.; Tsarev, A.; Janse van Rensburg, H.C.; Medvedev, S.; Demidchik, V.; Van den Ende, W.; Frolov, A. Glycation of Plant Proteins: Regulatory Roles and Interplay with Sugar Signalling? Int. J. Mol. Sci. 2019, 20, 2366

7- Mertens T., Kunz T., Gibson B.R. Transition Metals in Brewing and Their Role in Wort and Beer Oxidative Stability: A Review. J. Inst. Brew. 2022;128:77–95. doi: 10.1002/jib.699.

8- Lund M.N., Ray C.A. Control of Maillard Reactions in Foods: Strategies and Chemical Mechanisms. J. Agric. Food Chem. 2017;65:4537–4552. doi: 10.1021/acs.jafc.7b00882.

9- Davis, K. E., Prasad, C., Vijayagopal, P., Juma, S. and Imrhan, V. (2016). Advanced glycation end products, inflammation, and chronic metabolic diseases: Links in a chain?. Critical Reviews in Food Science and Nutrition, 56(6): 989-998.

10- Mania, I., Barone, C., Pellerito, A., Lagana, P. and Parisi, S. (2017). Trasparenza e Valorizzazione delle Produzioni Alimentari. ’etichettatura e la Tracciabilità di Filiera come Strumenti di Tutela delle Produzioni Alimentari. Ind Aliment. 56(581):18-22.

11- Sharma, R. K. and Parisi, S. (2017). Aflatoxins in Indian food products. In: Toxins and contaminants in Indian food products. Sharma, R. K. and Parisi, S. (Eds). Springer International Publishing AG, Cham.

12-- Ferrer E., Alegria A., Courtois G., Farre R., High-performance liquid chromatography determination of Maillard compounds in store-brand and name-brand ultra-high-temperature-treated cows’ milk. J. Chromat. A, 2000, 81, 599–606.

13-H eyns, K., & Eichner, H. (1966). The reaction of monosaccharides with lysine and peptides containing lysine. Hoppe-Seyler's Zeitschrift für Physiologische Chemie, 345, 154–170

14- Soria, A. C. and Villamiel, M. (2012). Non-enzymatic browning in cookies, crackers and breakfast cereals. In: Food biochemistry and food processing. Simpson, B. K. (Ed). Second Edition. John Wiley and Sons. p. 584-593

15- Singla, R. K., Dubey, A. K., Ameen, S. M., Montalto, S. and Parisi, S. (2018a). Analytical Methods for the Determination of Furosine in Food Products. In: Analytical Methods for the Assessment of Maillard Reactions in Foods.

16- Bicker, M.; Hirth, J.; Vogel, H. Dehydration of fructose to 5-hydroxymethylfurfural in sub- and supercritical acetone. Green Chem. 2003, 5, 280–284.

17--Kim, S. A., Oh, S. W., Lee, Y. M., Imm, J. Y., Hwang, I. G., Kang, D. H., & Rhee, M. S. (2011). Microbial contamination of food products consumed by infants and babies in Korea. Letters in Applied Microbiology, 53(5), 532-538. https://doi.org/10.1111/j.1472-765X.2011.03142.x

18-- BHARATE, S. S., BHARATE S. B. 2014. Non-enzymatic browning in citrus juice: chemical markers, their detection and ways to improve product quality. Journal of Food Science and Technology, 51(10)2271–2288. https://doi.org/10.1007/s13197-012-0718-8

19- Sabater, C., Montilla, A., Ovejero, A., Prodanov, M., Olano, A., & Corzo, N. (2018). Furosine and HMF determination in prebiotic-supplemented infant formula from Spanish market. Journal of Food Composition and Analysis, 66, 65–77. https://doi. org/10.1016/j.jfca.2017.12.004

20-Cemalettin Baltacı, Zeynep Akşit.(2016). Validation of HPLC Method for the Determination of 5-hydroxymethylfurfural in Pestil, Köme, Jam, Marmalade and Pekmez. Hittite Journal of Science and Engineering, 2016, 3 (2) 91-97. DOI: 10.17350/HJSE19030000037

21- Svecova,B. and Mojmir,M.A.C.H.(2017).Content of 5-hydromethyl-2-furfural in biscuits for kids.interdisciplinary toxicology,10(2),66-69.

22-Singla R K, Dubey A K, Ameen S M, Montalto S and Parisi S (2018b) The Control of Maillard Reaction in Processed Foods. Analytical Testing Methods for the Determination of 5 Hydroxymethylfurfural. In: Analytical Methods for the Assessment of Maillard Reactions in Foods. Singla R K, Dubey A K, Ameen S M, Montalto S and Parisi S (eds). Cham: Springer International Publishing. p. 15-26.

23- Yoshida I, Isagawa S, Kibune N, Hamano-Nagaoka M, Maitani T. 2007. Rapid and 527 improved determination of furan in baby foods and infant formulas by headspace 528 GC/MS. Journal of the Food Hygienic Society of Japan 48:83-89.

24--Ha T Nguyen -- H J Ine Van der Fels-Klerx , Ruud J B Peters , Martinus A J S Van Boeke (2015) Acrylamide and 5-hydroxymethylfurfural formation during baking of biscuits: Part I: Effects of sugar .typeOI: 10.1016/j.foodchem.2015.07.016

25- Nguyen, H.T. ; Van der Fels-Klerx. HJ. ;Peters, RJB. ; Van Boekel, MAJS. (2016). Acrylamide and 5-hydroxymethylfurfural formation during baking of biscuits: Part I: Effects of sugar type. Food Chemistry 192: 575–585.

26- Jandlova, M., and Kucerova, J.(2016). Hydroxymethylfurfural in syrups, doughs and in syrups biscuits. Mendelnet, 577-581

27- Devu, S. S. ; Dileepmon, R. ; Kothakota, A. ; Venkatesh, T. ; Pandiselvam, R. ; Garg, R. ; Khaneghah, A. M. (2022). Recent advancements in baking technologies to mitigate formation of toxic compounds: A review. Food Control, 108707.

28- Delgado-Andrade, C. ; Rufian-Henares, J. A. and Morales, F. J. (2009). Hydroxymethylfurfural in commercial biscuits marketed in Spain. Journal of Food and Nutrition Research., 48(1),14-19. jfnr-2009-1-p014-019-delgado.pdf

29-Charissou, A., Ait-Ameur, L., and Birloeuz-Aragon., I. 2007. Kinetics of formation of three indicators of the Maillard reaction in model cookies: Influence of baking temperature and type of sugar. J. Sci. Food Agric. 55:4532-4539.

30-Petisca C; Henriques AR, P.rez-Palacios T, Pinho O, Ferreira IMPLVO. (2014). Assessment of hydroxymethylfurfural and furfural in commercial bakery products. Journal of Food Composition and Analysis, 33(1): 20–25