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Comprehensive Analysis of Preservative Levels and Adulteration of Cake Samples in Egyptian Markets

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Abstract

In this study 90 cake samples were collected from the super markets present in some Egyptian governorates to assess their quality and safety (compliance to national &international regulations). The results showed that all samples were free of benzoic acid except nine samples contained sorbic and benzoic acid at more than 2000mg/kg which were (3360+105), (3090+102), (4800+105), (2838+151), (2505+108), (2717+145), (2659+142), (2173+19) ،(2535+108) mg/kg. The results also showed that the ratio of matched samples for sorbic acid concentration was 15.6% while the failed was 84.4% according to NFSA decision No.4 of 2020 and CODEX CXS 192-1995 Revision 2023 standards. These results reduced to 55.6% conformity ratio and 44.4% non-conformity at 2023 standards. This means that updating the regulations (NFSA decision No.5 of 2023) increased the compliance of the samples. This would raise the question about the balance between industry needs with consumer safety. Results also showed that all analyzed samples were free from potassium bromate, sulphites and SO_2. Concerning the food colors results showed that 9% samples contained an Allura Red AC level which exceeded the required limit of 300 μg/kg according to NFSA decision No. 4 of 2020. The Allura Red AC content in the tested samples ranged from(360 to 534) μg/kg. The studied samples were also exhibited all physical characteristics (weight, color, texture, Shape and Package Sealing, Sticking to Backing Cover and Design Defects, Smell and Insect Infestation and Foreign Materials).Concerning chemical composition of the cake samples results showed that some variations in The determined chemical constituent (protein, fat, carbohydrate). We found the microbial examination showed 90% of the samples were within the accepted limits according to (ES: 4037/2020).

Keywords: Adulteration, Benzoic acid, Cake, Egyptian market, Sorbic acid, Potassium bromate, Preservatives

1. Introduction

Bakery products are consumed in large quantities every day and play an important role in the human diet. The addition of functional ingredients to baked goods is becoming increasingly popular due to its ability to reduce the risk of some chronic diseases beyond basic nutritional functions [1]. The cake is one of the bakery products and its significance of cakes lies in their widespread popularity as one of the most favored bakery products globally. They have gained increasing popularity among consumers, serving as a versatile option for enjoyment as a snack with tea and juices or various events and celebrations [2].

The composition of cakes often includes ingredients such as wheat flour, eggs, milk, sugar, and baking powder [3]. Additionally, flavor enhancers and additives, such as cocoa and vanilla, as well as ingredients like fruit chops, nuts, or coconut, may be incorporated into cakes [4]. Wheat flour serves as the primary component in the cake industry, contributing its strength through the gluten protein it contains. This facilitates expansion during baking and provides robustness to the cake [5]. Egg proteins play a vital role in trapping air during whipping processes, crucial for imparting puffiness to the product. Additionally, eggs act as emulsifiers, preventing the separation of fat from the rest of the cake, thereby enhancing nutritional value [6]. Water functions to dissolve solid components in the mixture and also in the gelatinization process [7]. Sugar, on the other hand, imparts the desired sweetness to the final product and plays a role in achieving non-enzymatic browning, providing the cake with its desired color [8]. Fats shortening play a significant role in the sensory and phenotypic properties of the cake, contributing to its soft texture. They also influence the flavor of the product and facilitate the incorporation of air into the mixture, resulting in an

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increased cake size during baking [9].

Sweets and bakery products, including cakes and pastries, provide favorable conditions for the growth and reproduction of microorganisms, such as bacteria and molds. This is due to the abundant nutrients present in cake, and the moisture content essential for the growth of microorganisms. As a result therefore, it has become a potential source for the transportation of microorganisms [10]. Microorganisms plays a vital and beneficial role in the creation of bakery products [11], contributing to the formation of flavor and consistency. Nevertheless, these microorganisms can also adversely affect bakery products by altering their composition or causing damage, leading to spoilage [12].

Additionally, cakes, commonly filled, layered, or covered with whipped and butter cream, pose potential risks. These components typically do not undergo heat treatment and may harbor pathogens, providing an ideal environment for microbial growth and toxin production. This is attributed to their characteristics, including nearly neutral pH, high water activity, and rich nutrient content [13].

The spoilage of baked cereal products, attributed to mold, yeast, and spore-forming bacteria, is promoted by ambient temperature, pH (from 5.4 to 7.5) and water activity in the 0.75 to 0.98 range. The water activity (aw) is a particularly crucial factor influencing the spoilage of grain products, with many types of bread, cakes, and other baked goods having values exceeding 0.94 [14].

In accordance with the Egyptian Standard specifications for cake (ES: 4037/2020), the maximum permissible limits for total plate count in cakes are set at <10^4 CFU/g, and for yeast and mold, the limit is also <10^4 CFU/g.

Owing to the composition of cake ingredients, specific same liquid preparations may be prone to microbial contamination. So preservatives are utilized to shield these formulations, preventing any deterioration or alterations in the quality of the product. Therefore, preservatives (natural or artificial substances) are added to foods, cosmetics, and pharmaceuticals to extend their shelf life and prevent microbial growth, fermentation, and decomposition [15]. Sodium benzoate, sodium metabisulfite and nisin have inhibitory effects on spoilage microorganisms in cakes [16]. The use of synthetic chemicals, such as sorbic acid, acetic acid, ascorbic acid, and propionic acid and their salts, could be used as food preservatives to improve the safety and quality of cake products [17].

Widely utilized preservatives like benzoic acid (E210), sorbic acid (E200), and their respective salts (benzoates and sorbates) have garnered attention due to their antibacterial and antifungal properties [18]; [19]. Despite their low toxicity to mammals and being largely non-carcinogenic, these preservatives can morph into potential mutagens [18]. Necessitating stringent detection in food items. Legislative measures have established maximum permissible levels to curtail their presence in foods [20], yet exceeding these levels might induce adverse reactions, ranging from metabolic acidosis to convulsions , allergic reactions and asthma at higher doses [21; 22].

Sulphites, potent in releasing Sulphur dioxide (SO2), offer multifaceted advantages in food preservation, acting as bleaching agents, antimicrobials, and enzyme inhibitors among other roles [23; 24; 25; 26]. However, notwithstanding their prevalent use, sulphites have been implicated in eliciting asthmatic symptoms and have been correlated with anti-nutritional effects like thiamine degradation [25; 26].According to NFSA, Egypt permitted ranges of Preservatives in cakes as Sorbic Acid 1000 mg/kg and Benzoic Acid 1000 mg/kg.

Although potassium bromate effectively increases flour and flour product quality by oxidizing thiol groups in gluten proteins, thereby forming disulfide bonds [27; 28], its concurrent classification as a potential carcinogen and nephrotoxic substance has led to its prohibition in numerous jurisdictions [29; 30; 31].

Food colorants, deployed to enhance or preserve the sensory attributes of food products, can paradoxically present potential dangers. Some synthetic food colorants are recognized as harmful to aquatic species and potentially carcinogenic to humans, especially in substantial quantities [32].

Furthermore, numerous studies have elucidated the various genetic and health implications of different food colorants [33; 34].

It is paramount to meticulously declare all ingredients, including food colors, on food labels to safeguard consumers from potential allergic reactions and ensure adherence to regulatory standards. Thus, the precise identification of synthetic food colors becomes imperative for asserting food safety.

To avoid the risks shown with these preservatives, it is recommended that non-essential preservatives carry appropriate mutagenic/carcinogenic risk warning labels and should not be added to products for consumption by children less than 15 years of age.

This comprehensive study aims to provide insights into the quality and safety of the cakes available in the Egyptian local markets. By assessing both chemical and microbiological aspects, concerning adulteration i.e., materials added & types, Detection of adulterants in cakes products, Study the types of these additives and to inspect their effect on food quality as well as safety of food & consumers.

This research will contribute to a better understanding of the cake samples' overall composition and potential risks associated with chemical preservatives.

2. Materials and Methods

2.1. Collection and preparation of cake samples

A total of 90 samples were collected from super markets at some governorates representing 18 brands (commercial name) (Produced by food companies and have brand names, C1 to C18) from Egyptian governorates, i.e., Cairo G1 (21 samples), Giza G2 (19 samples), Qalyubia G3 (14 samples), Alexandria G4 (10 samples), Menoufia G5 (10 samples), Alsharqia G6 (10 samples) and Algharbia G7 (6samples). All samples were collected and directly stored at room temperature away of sun light.

The samples were taken collected from the supermarkets shelves at room temperature. They were in a good state and at the first two months of the shelf life. All samples were packed in polyethylene packages. And were physically examined and the acceptability parameters were considered such as color, shape, texture, and smell. The senseorial tests were conducted using both sensory evaluations using ten trained panelists to assess color, smell, shape, and texture. And transferred laboratory under refrigeration. Chemical composition and microbial load were also tested. Each tested sample was prepared by mixing 10 samples of the same batch were taken from each brand to represent one sample out of 90 samples. All collected samples were packed in aluminized polyethylene and stored in refrigeration to minimize any potential changes or degradation that could occur at room temperature, ensuring the integrity of the samples remains unchanged for accurate testing.

Fig. 1. Some of cake samples

2.2. Processing and production of cake

Cake processing in the factories entitled previously for that produce was done in accordance with Ceserani & Kinton [35] as follows: Using an electric mixer, the solid raw materials, i.e., wheat flour (400 g), baking powder (0.5 g), and potassium sorbets were combined. Sugar (200 g) and butter (125 g) were creamed until a light and fluffy batter was formed. 300 g of eggs were beaten for five minutes in a homogenizer, then 200 g of liquid milk and 5 mL of vanilla essence were added to the homogenized eggs. The resulting fluffy batter was combined with the solid mixture and thoroughly mixed to achieve a uniform texture then fermented before being poured into cake pans that had been greased. This mixture was baked for fifteen minutes at 190°C in the oven. Following baking, the cakes were allowed to cool for one hour at room temperature before being sealed in an airtight transparent plastic container and placed inside low density polyethylene bags.

2.3. Determination of chemical composition of Cake Samples

Ten random samples were taken for chemical analysis. These samples were stored at room temperature and transported under refrigeration to the faculty of agricultural, Cairo University lab for chemical determination. Chemical composition i.e. fat, protein and Carbohydrate were determined according to AOAC [36].

2.4. Physical examination of collected samples

Each of the ninety sample packages were checked for holes, rips, and other damage. Packages were also examined for of molds, spoilage or any foreign items. Acceptability parameters i.e. color, shape, and texture and odorless of the cake samples were examined overall and The tests for color, shape and texture were conducted using both sensory evaluations and involved ten trained panelists to assess the samples based on color, shape, and texture. In addition to verifying that the aluminum foil's interior packaging was intact and correctly sealed.

2.5. Microbiological examination of cake samples

Microbial load examination: Ten random samples were taken for total microbial load examination according to Chiang et al. [37]. Yeasts and molds were determined according to Spencer [38]. All microbial load examinations were carried out at the faculty of agriculture, Cairo University microbiological lab.

2.6. Determination of benzoic and Sorbic acids

The benzoic and sorbic acids were determined in cake samples by using Reversed-Phase High Performance Liquid Chromatography (RP-HPLC) at (QCAP Lab) according to El Sayed et al. [39].

2.7. Determination of bromate content of cake samples

The Bromate content in cake samples was determined by ion chromatography-mass spectrometry at (QCAP Lab) according to Aggrawal and Rohrer [40].

2.8. Determination of Sulfite and SO2 in cake samples

The Sulfite and SO2 were determined in cake samples by using Liquid Chromatography Mass Spectrometry at (QCAP Lab) according to according to Carlos and de Jager [41].

2.9. Determination of food colorants in cake samples

Forty-six random cake samples were collected to determine their content of synthetic colors by using High Performance Liquid Chromatography (HPLC) at (QCAP Lab) according to Yoshioka [42].

2.10. Statistical Analysis

The sorbic acid samples results were subjected to variance analysis (ANOVA) to determine the presence of statistically significant differences among the means. To compare the means, Tukey's Honestly Significant Difference (HSD) test was employed at the 5% significance level, providing detailed pairwise comparisons between groups. The analysis was conducted using the PROC ANOVA procedure in the Statistical Analysis System and the chemical composition data were subjected to variance analysis. To compare the means, t-tests were employed at the 5% significance level [43].

3. Results and Discussion

3.1. Chemical Composition of Cake Samples and Label Accuracy

Accurate food labels are crucial for consumer trust and regulatory compliance. They provide essential information for consumers to make informed dietary choices. This study evaluated the chemical composition (protein, fat, carbohydrate) of ten randomly selected branded cake samples purchased from supermarkets.

The results in Table (1) showed that the average protein content in the cake samples was 13.40%, with a significant difference ($P < 0.05$). Similarly, the average carbohydrate content in the cake samples was 60.29%, with a significant difference ($P < 0.05$), while the average fat content was 15.70%, without any significant difference ($P > 0.05$). The results revealed discrepancies between the labeled values and the actual content of protein and carbohydrates in the cake samples. While the fat content matched the label information, the protein and carbohydrate levels were higher than declared. Several factors could contribute to these discrepancies: Variations in Raw Materials, Manufacturing Inconsistencies, Measurement errors, Processing variations, Analytical or Labeling Errors, Outdated data, and Calculation mistakes, Data entry errors.

Table 1. The Comparison between values the information on the product label and ten samples from local markets with use one sample T-Tests.

Variable	The information on the product label	Mean	Std Err	t Value	Pr > |t|
Protein	4.8	13.405±	1.6455	5.23	0.0005
Fat	13.7	15.703±	0.9339	2.14	0.0606
Carbohydrates	53.3	60.298±	2.9196	2.40	0.0401

3.2. Product Quality Assessment

This section evaluates the physical characteristics of the cake samples, focusing on net weight, color, and texture.

a. Net Weight: According to the Egyptian Standard Specification for cake (ES: 4037/2020), the net weight of a packaged food product must be clearly stated and must match the declared quantity. In this study, all cake samples (S1 to S90) exhibited accurate net weights.
b. Color: AS noted by Zielińska and Pankiewicz [45], the color of baked goods is directly influenced by the ingredients used. Color is an important factor influencing consumer choice and satisfaction, impacting taste perception and enjoyment [46]. All cake samples (S1 to S90) exhibited acceptable color consistency.
c. Texture: Texture, appearance, and storage stability are crucial factors affecting consumer perception of desserts [47; 48] highlight appearance as a primary criterion for food purchasing decisions. While all cake samples (S1 to S90) displayed a consistent texture.
d. Shape and Package Sealing: The Egyptian Standard (ES: 4037/2020) [49] specifies requirements for cake shapes. All cake samples (S1 to S90) complied with these standards in terms of shape. Additionally, all branded samples (S1 to S90) had proper packaging and sealing.
e. Sticking to packing Cover and Design Defects: Ideally, cakes should not stick to their packing covers after packaging. All cake samples (S1 to S90) exhibited no sticking and displayed no design defects.
f. Foreign Materials: According to the Egyptian Standard Specification for cake (ES: 4037/2020), the presence of foreign materials in food products is unacceptable. Fortunately, none of the ninety samples contained any foreign materials.

3.3. Microbiological Examination

3.3.1. Aerobic Plate Count (APC) (CFU/g)

Importance of APC: The aerobic plate count (APC) is a commonly used indicator of overall microbial contamination in food products. It could reflect hygiene practices during processing, storage, and handling. High APC suggested potential spoilage sanitation & low hygienic conditions and possible presence of pathogens [50].

Egyptian Standard and Results:

The Egyptian Standard for Cakes (ES: 4037/2020) [49] specifies a maximum permissible limit of 10,000 CFU/g for APC. Ten random samples of commercially produced cakes were collected from supermarkets and analyzed. The results (presented in Table 2) showed that 90% of the samples were within the acceptable limit. However, 10% of the samples exceeded the limit, exceeding 300,000 CFU/g.

High APC could indicate contamination from various sources, such as: Contaminated water or raw materials used in production, Unsanitary processing equipment or utensils and Inadequate sanitation practices by food handlers.

While, exceeding the APC limit suggested potential hygiene issues during processing or handling. This raises concerns about product quality and safety.

Table 2. Microbial Count of Ten Randomly Selected Commercial Cake Samples from Egyptian Markets

Companies	Aerobic total plate count. cfu/g	Moulds cfu/g	Yeasts cfu/g	Anaerobic Plate Count cfu/g
C1	< 10	< 10	< 10	< 10
C2	< 10	< 10	< 10	< 10
C4	< 10	< 10	< 10	< 10
C5	< 10	< 10	< 10	< 10
C7	< 10	< 10	< 10	< 10
C8	< 10	< 10	< 10	< 10
C10	800	< 10	< 10	< 10
C12	> 300 000	< 10	< 10	< 10
C14	< 10	< 10	< 10	< 10
C18	< 10	< 10	< 10	< 10

3.3.2. Yeast and Mold Count (CFU/g): Importance and Regulations

Fungi, including yeasts and molds, could negatively impact the quality and safety of food products. In raw materials and pre-baked goods, fungal contamination could cause spoilage and reduce shelf life. While thermal treatment during baking could eliminate some fungi, post-baking contamination poses a significant risk to the microbiological stability of cakes, particularly when it occurs through airborne transmission, product handling, or insufficient equipment sterilization [51].

Mold growth on cakes not only compromises their visual appeal and texture but also leads to economic losses for food manufacturers [52].

Regulation and Results: Following Egyptian Standard for cakes ES 4037:2020[49], cakes should be free from yeast and mold. All cake samples analyzed in this study (presented in Table 2) complied with this standard, indicating acceptable microbiological quality.

In contrast, a study by Jamshidi & Shokri [52] reported a high rate of contamination of the analyzed cake samples, the mold contamination was recorded at 20.5% and yeast at 13.6%, In another study conducted by Hag et al. [53] who reported that 5.1% of cake samples had fungal contamination.

On the other hand, a study conducted by Hassanzadazar [54] who found that fungal and yeast contamination was detected at a level of 48.39% and Total plate count at a level of 64.51% in cake samples, which contradicts with our study.

A high rate of bacterial, mold, and yeast contamination necessitates the use of various techniques to control microbial growth, such as raising worker awareness of sanitary issues, routinely cleaning and disinfecting equipment, improving confectionery sanitation, using appropriate food storage techniques, and quickly preparing confections [52].

3.4. Chemical Preservative Content in Cake Samples

Emerging concerns about the widespread use of chemical preservatives, such as sorbic Acid (SA) and Benzoic Acid (BA), in food and beverages are increasing scrutiny on their use and regulation [55]. In this study, 90 commercial cake samples collected from seven governorates were evaluated to assess the proportions of chemical preservatives, including sorbic acid, benzoic acid, potassium bromate, and SO_2 and their reliable to standers.

3.4.1. Sorbic Acid and Benzoic Acid:

The statistical analysis of 90 commercial cake samples (S1 to S90) showed no significant differences between the seven governorates (G1 to G7). However, there were differences between companies (C1 to C18) and individual samples (S1 to S90), $p<.05$.

The data in tables 5 and 6 were analyzed by an ANOVA test using the INSTEAD statistical model to study the effect of significant differences between samples from different companies within each governorate.

The results showed that highly significant difference between the samples produced from different companies. A separation test was also conducted between the averages to study the significant differences between the levels of each variable studied using the Tukey test.

The results showed companies C4, C8, C17 and C18 added high amount of a Sorbic acid excessively more than the regulation standard. While companies C3, C5, C9 and C11, showed no significant difference in the addition of Sorbic acid.

The results also revealed that the values had highly significantly differences between the old and new regulations. NFSA decision No. 4. For the year 2020 and NFSA decision No. 5. For the year 2023.

National and global regulations for additives in bakery products, such as the National Food Safety Authority (NFSA) decision No. 4 of 2020 [49] and CODEX CXS 192-1995 Revision 2023 [56], allow the addition of sorbic acid at concentrations not exceeding 1000 μg/kg, and benzoic acid at concentrations not exceeding 1000 μg/kg, either alone or combined. In contrast, Egyptian legislation (NFSA decision No. 5 of 2023) [57] and EU Legislation Commission Regulation (EU) No. 1129/2011 [58] state that Sorbic acid is allowed at concentrations not exceeding 2000 μg/kg, but in this case, benzoic acid is not allowed to be added with sorbic acid.

The results of the 90 samples (S1 to S90) showed that benzoic acid was absent in all samples except for nine samples monitored by companies C4 and C18. In these samples, both sorbic acid and benzoic acid were found to exceed 2000 μg/kg. The amounts of sorbic acid and benzoic acid in these nine samples were as follows:

(S44: 3360 μg/kg +105 μg/kg),(S78: 3090 μg/kg +102 μg/kg),(S77: 4800 μg/kg +105 μg/kg),(S86: 2838 μg/kg +151 μg/kg),(S67: 2505 μg/kg +108 μg/kg),(S84: 2717 μg/kg +145 μg/kg),(S83: 2659 μg/kg +142 μg/kg),(S74: 2173 μg/kg +19 μg/kg) and (S73: 2535 μg/kg +108 μg/kg).

These ratios are contrary to NFSA decision No. 5 of 2023[57] and EU [58] legislation. Additionally, there was one sample from company C8 that contained both sorbic acid and benzoic acid within national and international regulations, with the respective concentrations being: S49: 368 μg/kg +319 μg/kg.

The analysis of the 90 samples (S1 to S90) collected from seven governorates (G1 to G7) recorded that all samples contained sorbic acid in varying concentrations, ranging from 368 to 4800 μg/kg, as shown in Table3.

Table 3: Sorbic acid levels (mg/kg) in 90 samples from companies all over 7 governorates.

G / C	Cairo G1	Giza G2	Qalyubia G3	Alexandria G4	Menoufia G5	Alsharqia G6	Algharbia G7
C1	S1 SV=3224	S22 SV=2820 S23 SV=2607	S41 SV=3025	S 55 SV=2736	S65 SV=1233	S75 SV=1411 S76 SV=1308	S85 SV=1280
C2	S2 SV=1870	S24 SV=1287	S42 SV=1943	-	-	-	-
C3	S3 SV=1131	S25 SV=993	S43 SV=900	-	-	-	-
C4	S4 SV=3099 S5 SV=3320	S26 SV=3259 S27 SV=3351	S44 SV=3714 S45 SV=3360	S56 SV=2289 S57 SV=2467	S66 SV=2381 S67 SV=2505	S77 SV=4800 S78 SV=3090	S86 SV=2838
C5	S6 SV=1419	S28 SV=1196	S46 SV=1033	-	-	-	-
C6	S7 SV=1858	S29 SV=1885	-	-	-	-	-
C7	S8 SV=1675 S9 SV=1878	S30 2052SV= S31 SV=1568	S47 SV=1309 S48 SV=1738	S58 SV=1818 S59 SV=2016	S68 SV=1720 S69 SV=2190	S79 SV=1581 S80 SV=1884	S87 SV=1739 S88 SV=1309
C8	S10 SV=3626	S32 SV=3725	S49 SV=368	S60 SV=3188	-	-	-
C9	S11 SV=1262	S33 SV=1309	S50 SV=1175	-	-	-	-
C10	S12 SV=765	S34 SV=995	S51 SV=778	S61 SV=750	-	-	-
C11	S13 SV=600	S35 SV=1787	S52 SV= 1893	S62 SV=1654	-	-	-
C12	S14 SV=2553	S36 SV=1309	S53 SV=1794	-	-	-	-
C13	S15 SV=2272	S37 SV=2022	S54 SV=2036	-	-	-	-
C14	S16 SV=2686 S17 SV=2862	S38 SV=2218 S39 SV=2058	-	-	S70 SV=1598 S71 SV=993	-	S89 SV=2064 S90 SV=1377
C15	S18 SV=660 S19 SV=993	-	-	S63 SV=998	S72 SV=1262	S81 SV=750 S82 SV=775	-
C16	S20 SV=1931	S40 SV=2071	-	-	-	-	-
C17	S21 SV=2385	-	-	S64 SV=2829	-	-	-
C18	-	-	-	-	S73 SV=2535 S74 SV=2173	S83 SV=2659 S84 SV=2717	-

S=Sample NO.; SV= sorbic acid value

Table (4) provides a comparative analysis of cake samples from various companies across different governorates in Egypt.

Table 4: Number of Violated and Accepted Cake Samples from Various Companies in Different Governorates in Egypt: Comparison of Sorbate Concentrations According to NFSA1 and CODEX2 vs. NFSA3 and EU4 Criteria

		NFSA[1] and CODEX[2]		NFSA[3] and EU[4]	
Company	Sample NO.	Accepted	Violated above accepted level of 1000 µg/kg	Accepted	Violated above accepted level of 2000 µg/kg
C1	9	0	9	4	5
C2	3	0	3	3	0
C3	3	2	1	3	0
C4	13	0	13	0	13
C5	3	0	3	3	0
C6	2	0	2	2	0
C7	14	0	14	11	3
C8	4	1	3	1	3
C9	3	0	3	3	0
C10	4	4	0	4	0
C11	4	1	3	4	0
C12	3	0	3	2	1
C13	3	0	3	0	3
C14	8	1	7	3	5
C15	6	5	1	6	0
C16	2	0	2	1	1
C17	2	0	2	0	2
C18	4	0	4	0	4
Total	90	14	76	50	40

[1]The National Food Safety Authority decision No. 4. for the year 2020.
[2]CODEX CXS 192-1995. Revision 2023.
[3]The National Food Safety Authority No. 5. for the year 2023.
[4]Commission Regulation (EU) No. 1129/2011.

Table (5) categorizes the samples based on whether they meet or violate the sorbate concentration criteria set by the National Food Safety Authority (NFSA) [49] and the Codex Alimentarius (CODEX) [56], as well as the updated NFSA [57] and European Union (EU) regulations [58]. This comparison highlights the compliance of the samples with national and international standards for sorbic acid concentrations.

Table 5: Mean Excess Sorbic acid Concentrations (µg/kg) and Their Standard Errors in cake Samples from Various Companies in

Company	N.	NFSA[1] and CODEX[2] above level of 1000 µg/kg	NFSA[3] and EU[4] above level of 2000 µg/kg
C1	9	1182.7^{a-f}±848.78	490.2^{e-i}± 496.04
C2	3	700.0^{c-j}±359.52	0.0^{j}±0
C3	3	43.7^{h-j} ±75.63	0.0^{j}±0
C4	13	2113.3^{a}±674.97	1421.0^{a-e}±928.07
C5	3	216.0^{f-j}±193.77	0.0^{j}±0
C6	2	871.5^{c-j}±19.09	0.0^{j}±0
C7	14	748.4^{d-j}±255.99	18.4^{i-j}±51.37
C8	4	1884.8^{ab}±1277.98	1134.8^{b-g}±791.66
C9	3	248.7^{f-j}±67.98	0.0^{j}±0
C10	4	0.0^{j}±0	0.0^{j}±0
C11	4	583.5^{d-j}±401.10	0.0^{j}±0
C12	3	885.3^{c-j}±627.00	184.3^{g-j}±319.27
C13	3	1110.0^{b-f}±140.47	110.0^{h-j}±140.47
C14	8	982.9^{b-i}±634.26	236.0^{f-j}±342.89
C15	6	43.7^{h-j}±106.96	0.0^{j}±0
C16	2	1001.0^{b-h}±98.99	35.5^{h-j}±50.20
C17	2	1607.0^{ac}±313.95	607.0^{d-j}±313.95
C18	4	1521.0^{ad}±244.10	1521.0^{ad}±244.10

[1] The National Food Safety Authority decision No. 4. for the year 2020.
[2] CODEX CXS 192-1995. Revision 2023.
[3]The National Food Safety Authority No. 5. for the year 2023.
[4]Commission Regulation (EU) No. 1129/2011 it is stated a maximum limit of 2000 mg without adding benzoates.

Table 6: Mean of Sorbic acid Concentrations in cake samples (μg/kg)

Company	N.	(μg/kg)
C1	9	836.4^{cd}±179.7
C2	3	350.0 ^{ed}±181.9
C3	3	21.8^{e}±21.8
C4	13	1767.2^{a}±170.6
C5	3	108.0^{e}±69.5
C6	2	435.8^{ed}±251.6
C7	14	383.4 ^{ed}±78.1
C8	4	1509.8 ^{ab}±375.7
C9	3	124.3^{e}±58.3
C10	4	0^{e}±0
C11	4	291.8 ^{ed}±144.1
C12	3	534.8 cd^{e}±239.9
C13	3	610.0cd^{e}±229.4
C14	8	609.4 cd^{e}±156.3
C15	6	21.8^{e}±21.8
C16	2	518.3 ^{cde}±280.5
C17	2	1107.0 ^{bc}±315.8
C18	4	1521.0^{ab}±79.9

Means with the same letters do not statistically differ according to Tukey's Studentized Range (HSD) at a probability level of 0.05.

Comparing the results of the 90 samples (from S1 to S90) with national and international regulations as shown in Table 5, the results were as follows:

The ratio of matched samples was 15.6%, while the ratio of failed samples was 84.4% in accordance with NFSA decision No. 4 of 2020 [49] and Codex standards [56].

When the 90 samples (from S1 to S90) were compared to the updated NFSA Decision No. 5 of 2023 [57] and European Union regulations [58], the conformity ratio was 55.6%, while the non-conformity ratio was 44.4%.

Key Points:

The cake samples exhibited a higher non-compliance rate with the older regulations (NFSA decision No. 4 of 2020). Updating the regulations (NFSA Decision No. 5 of 2023) [57] and adopting less strict standards (EU regulations) resulted in a significant increase in compliance. This raises a question about whether the new standard prioritizes industry compliance over stricter safety measures for consumers. A comprehensive scientific risk assessment is required to compare the safety implications of the different regulations for consumers. Are the older, stricter standards truly necessary, or does the EU MRL [58] offer a safe alternative? The question of: It's difficult to definitively say if the EU MRL is "safer" without more information. The NFSA conformity assessment program aims to ensure the safety and security of food and reinforce consumer confidence in the food control authority.

Further analysis and scientific evaluation are needed to determine if the EU MRL [58] provides an adequate level of protection for consumers or not.

Studies conducted in most countries show that benzoic acid and sorbic acid are often used as preservatives, either alone or together. A study conducted in Egypt by El Sayed et al. [39] found that sorbic acid levels in cakes ranging from 288 to 659 μg/kg, while benzoic acid was not detected. In the same line in Pakistan, Mustafa et al. [59] found that benzoic acid (BA) concentrations ranged from 314 to 457 μg/kg, while sorbic acid (SA) concentrations ranged from 597 to 859 μg/kg in tested cake samples. Costa et al. [60] in Portugal found an average concentration of 1298 μg/kg sorbic acid in samples of cakes and baked goods, and no benzoic acid was detected. Chaleshtori et al. [61] in Iran concluded that sorbic acid and benzoic acid were tested in cake samples, and the results showed that all samples (except one cake sample) contained SB and BA levels below the legal limit.

The results of these studies do not correspond to our study, where our study showed the presence of sorbic acid in a concentration ranging from 368 to 4800 μg/kg. This may be the reason for the difference between our study and other studies in which the present study was sampled from several different regions and governorates, whereas in the other samples were taken from one specific area, and that area could have strictly followed regulations and legislation.

3.4.2. Potassium Bromate (KBro3)

Potassium bromate is classified as carcinogenic to humans (Group 2B) by the IARC [62] and can lead to various health problems. Despite being prohibited nationally and internationally (NFSA, 2020 [49]; European Parliament and the Council of the European Union, 2008) [63], it is still used illegally due to its low cost and high effectiveness in improving low-quality gluten [64] In this study, ninety commercial cake samples from seven different governorates across Egypt were analyzed to identify possible violations of regulations on the use of potassium bromate. The results showed that all ninety samples were free of potassium bromate, consistent with the ban on its use in bakery products in Egypt.

The study confirmed that the total absence of potassium bromate in all analyzed cake samples, the results are in complete contradiction with the practices observed in some other countries. Studies in some countries show that potassium bromate is still widely and frequently used in many regions despite being banned in many countries.

Ail et al. [65] in Nigeria determined the residual of potassium bromate in cake samples, and the results revealed that 20% of cake samples contained residual potassium bromate. On the other hand, Salim et al. [66] In Tobruk, Libya, found that all samples of bakery products analyzed contained different levels of potassium bromate, and it was noteworthy that the lowest concentration found of potassium bromate was 85 times higher than the permissible safe level, while the highest concentration was 310 times higher than what was considered life-threatening and unsafe for human consumption.

In another study by Hama et al. [67] who determined the amount of potassium bromate in 30 of analyzed bakery product samples, the results revealed that all 30 samples contained potassium bromate residues in their products in different concentrations above permissible values.

The results in this research showed that all analyzed cake samples were completely free of bromate. In many countries, bromate is still widely used, often in high concentrations, despite the known health risks of bromate and its ban in many countries. These differences in bromate use can also lead to different health consequences. In countries where bromate is still used, people are at higher risk of exposure to carcinogens, which can lead to long-term health problems, including an increased risk of cancer [29, 30, 31]. In contrast, the samples we studied were free of bromate, suggesting that consumers in the regions we studied are not exposed to these risks.

3.4.3. Sulphites

According to NFSA (decision No. 4 of 2020) [49], who reported that the permitted addition of sulphates to bakery products is not more than 50 μg/kg.

The results showed that all samples were free of sulphites and SO_2. None of the ninety samples showed the presence of sulfur, or SO_2, aligning with the product labeling information. In contrast, a study by Jain & Mathur [68] who revealed presence of sulfates in tested cake samples, although the label did not indicate the presence of sulfates. The authors also found that the average concentration of sulfates in cake samples was less than 10 mg/kg, which was similar to that reported in Australia and New Zealand by FSANZ [69].

Also, the results of the present studied varied with those by Leclercq et al. [70], as sulfates were found in the cake samples analyzed.

3.4.4. Food Colorants

Forty-six cake samples cake samples were evaluated for their content of synthetic food colors, including Allura Red AC, Sunset Yellow FCF, Amaranth, Ponceau 4R, Erythrosine, Fast Green FCF, Patent Blue V, Tartrazine, Indigo Carmine, and Carmoisine. The results showed that 9% of the tested samples contained Allura Red AC levels that exceeded the required limit of 300 μg/kg as per NFSA decision No. 4 of 2020[49]. The Allura Red AC content in the tested samples ranged from 360 μg/kg to 534 μg/kg, as shown in Table 7.

Table 7: Results of Testing 46 Cake Samples in Egypt Markets color additives.

Statistics	Accepted	Violated (above accepted level of 300 μg/kg)
Allura rad AC		
No. of samples	42(N.D)	4
Min	-	360
Max	-	534
Mean+ SD	-	435.25 + 72.514

Other colorant Ponceau 4R, Erythroslne, fast green FCF, Patont blue V, Tartrazin, lndigo Carmino ,and Carmoisine (Not Detect).

This overuse of Allura Red AC (E129), an azo dye may pose health risks such as allergies, cancer, ADHD, food intolerance, and multiple sclerosis [71]. In addition, Macioszek et al. [72] demonstrated the genotoxicity of two commonly used food dyes, quinoline brilliant black and yellow, on human lymphocytes. A study on the toxic effects of food dyes found that methylene blue caused abnormal sperm morphology in adult albino mice [73]. In a study on the effects of artificial food dyes on children, a significant correlation was found between the severity of the children's illness and the number of products containing artificial dyes consumed [74]. The results of a study showed a significant correlation between the prevalence of ADHD in children and the use of artificial dyes [75]. The long-term effects of these compounds are very important [76]. Food dyes can also cause allergic, metabolic and idiosyncratic reactions, or affect blood pressure, mitochondrial respiration, liver, kidney and hormone function, and vitamin levels [77]. It is essential to exercise moderation in consuming colored products, particularly for children, to minimize exposure to excessive preservatives and colorings.

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