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Microbial Quality of Halawet Eljibn, an Arabic Sweet Sold in the Retail Market in Jordan

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HIGHLIGHTS

- The mean averages of moisture content, pH, and titratable acidity of halawet eljbin market samples were 45.5, 6.3, and 0.28%, respectively.
- Market halawet eljbin samples had mean aerobic plate, Lactic Acid Bacteria, and yeast and mold counts of 6.6, 6.8, and 3.2 log Colony Forming Unit (CFU)/g, respectively.
- The mean average count of fecal coliforms in halawet eljbin market samples was 4.1 log CFU/g.
- The mean average count of pathogenic *Staphylococcus aureus* in halawet eljbin market samples was 2.0 log CFU/g.

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Acronyms and abbreviations
APC=Aerobic Plate Count
CFU=Colony Forming Unit
FDA=Food and Drug Administration
LAB=Lactic Acid Bacteria
RTE=Ready-to-Eat

ABSTRACT

Background: Halawet eljibn is a popular Ready-to-Eat sweet in the Levant region. However, its non-machinery preparation and lack of final heating increase the risk of contamination by microorganisms that can cause food-borne illnesses. The study aimed to investigate the numbers of microorganisms present in commercially produced halawet eljibn in Jordan.

Methods: Sixty samples of halawet eljibn were collected from 15 sweet shops in Amman, Jordan at two intervals. Two sample units were taken from each sweet shop, and two reference samples were prepared under hygienic conditions for comparison purposes. The study evaluated the chemical properties of the samples, including moisture content, pH, and titratable acidity, and also assessed their microbiological quality through Aerobic Plate Count, Coliform Count, Lactic Acid Bacteria count, *Staphylococcus aureus* count, and yeast and mold count analyses.

Results: In this study, the samples exhibited a moisture content ranging from 40.9 to 49.8%, a pH range of 5.7 to 6.7, and acidity levels varying between 0.14 and 0.45%. The average Aerobic Plate Count and the counts of coliforms, Lactic Acid Bacteria, yeast and mold and *S. aureus* for halawet eljibn market samples were 6.6, 4.1, 6.8, 3.2, and 2.0 log Colony Forming Unit (CFU)/g, respectively. Counts of interval I (10th October-12th December) samples were significantly higher than those of interval II (19th December-10th January). The same average counts of the reference samples were significantly lower (2.3, <10, 1.6, 1.4, and <10 log CFU/g, respectively).

Conclusion: The study findings indicate that halawet eljibn provides an appropriate environment for microbial growth. The observed non-adherence to optimal hygienic practices during the production and handling of halawet eljibn underscores the need for more rigorous regulations to ensure its microbiological quality and safety.

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Introduction

Arabic sweets are known for their diversity in texture and flavor, ranging from light and flaky to rich and buttery, that can be both sweet and savory, with a variety of aroma and spices. They can be prepared in a variety of ways, from deep-frying to baking, and are often left to cool before serving. The used ingredients in these sweets can include pastry or kataifi (shredded filo pastry), semolina or flour, and sweeteners such as honey, aromatic syrups, or sugar. Additionally, many Arabic sweets include puddings, candies are filled or garnished with ingredients such as nuts, sweet cheese, dates, apricots or other fruits (Salloum et al., 2013).

Halawet eljibn is a traditional Arabic sweet that is popular in the Levant region. The origin of this sweet is not well-documented and has been a topic of debate, with some claiming it to be from the city of Hama, and others claiming it to be from the city of Homs, Syria. Despite this case, it has gained widespread popularity throughout the Middle East region. The main ingredients in this sweet are semolina flour and white unsalted cheese. The preparation process involves mixing these ingredients together to form soft dough, which is then spread out thinly on a flat surface and rolled into large rounds prior to be filled with cream, topped with syrup, and garnished with crushed pistachios. This sweet is similar to other traditional sweets that use cheese and semolina as the main ingredients, such as mustafakemalpasa and hosmerim in Turkey (Akpinar-Bayizit et al., 2009), and Dêguê in Ivory Coast (Christelle et al., 2021). These traditional sweets may differ in preparation methods and additional used ingredients.

Halawet eljibn is a Ready-to-Eat (RTE) food that is traditionally consumed with no additional heating or sterilizing steps. The lack of a final heating step before consumption, accompanied with the non-machinery preparation method, can increase the risk of contamination with bacteria, yeasts, and molds, so, contamination of halawet eljibn is a major concern as it can lead to food-borne illnesses and outbreaks. Like many other food products, halawet eljibn can be contaminated with microorganisms throughout the production process. The use of contaminated raw materials, such as white cheese, can introduce microorganisms into the dough. During preparation, the dough may be contaminated by microorganisms present on processing surfaces or equipment, or from workers' hands preparing the dough. Improper storage or handling of the finished product can also lead to the growth of microorganisms, potentially including pathogens. In case proper sanitation and hygienic practices are not followed during the production, this type of risk will be increased (Mwamakamba et al., 2012).

Despite its popularity as a sweet and significant market share in the sweet bakery industry in the region, no scientific research on halawet eljibn is existed. So, this study was carried out to determine the numbers of microorganisms which present in commercially produced halawet eljibn in Jordan, in order to evaluate the hygienic conditions during preparation. A sample of produced halawet eljibn under hygienic conditions as a reference control for comparison was used.

Materials and methods

Sample collection

A total of 60 samples were collected from 15 sweet shops in Amman, Jordan at two different intervals, separated by a two-month period. Two sample units were obtained from each shop at each visit, resulting in a total of 30 samples collected during the first interval (10^{th} October-12^{th} December 2021) when the average daily temperature range was 15.4 to 27.2 °C, and 30 samples collected during the second interval (19^{th} December-10^{th} January 2021) when the average daily temperature range was 5.9 to 14.8 °C. Samples were transported to the laboratory using an icebox within 1 h of purchase to ensure the preservation of sample integrity. The samples were purchased as offered to customers, and the weight of each sample unit was approximately 1 kg. The obtained samples were analyzed for microbiological quality to identify any potential food safety concerns. The presence of *Staphylococcus aureus* was evaluated in all market and reference samples of halawet eljibn using the brain heart infusion broth clotting assay as outlined in the Food and Drug Administration (FDA) bacteriological analytical manual (FDA, 1998).

Chemical analysis

The moisture content, titratable acidity, and pH was determined using the guidelines established by the Association of Official Analytical Chemists (AOAC, 2005). The moisture content was considered by atmospheric oven technique. The titratable acidity of the samples was quantified by titration with sodium hydroxide (NaOH) (Oxoid, UK). The pH was measured by immersion of a pH-sensitive electrode in a dilution of the sample in distilled water, using a calibrated pH meter (Orion, UK).

Microbiological Tests

Aerobic Plate Count (APC) and the counts of coliforms, yeasts and molds, and *S. aureus* were determined as described in the FDA's bacteriological analytical manual (FDA, 1998). The enumeration of Lactic Acid Bacteria (LAB) in the samples was performed according to the methodology described in ISO15214: 1998 (ISO, 1998). Microbial analysis in this study utilized various media to assess distinct bacterial populations. Mesophilic aerobes

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were cultured on plate count agar (Oxoid, UK) at 35 °C for 48 h. Yeasts and molds were quantified using Dichloran 18% Glycerol (DG18; Oxoid, UK) agar at 25 °C for 5 days. Coliforms were enumerated using Violet Red Bile Agar (VRBA; Oxoid, UK) at 35 °C for 24 h. LAB were examined on deMan Rogosa and Sharp (MRS; Oxoid, UK) agar at 30 °C for 72 h, and *S. aureus* was cultured on baird parker agar (Oxoid, UK) at 35 °C for 48 h. These media were sterilized at 120±1 ºC for 15 min consequently in order to prepare dilutions for microbiological testing. To obtain samples for microbiological analysis, 25 g of halawet eljibn was collected from various regions of the tray using pre-sterilized equipment. The samples were first weighed, and then they were placed into a sterile stomacher bag, followed by the addition of 225 ml of peptone water (Oxoid, UK). The bag was homogenized in a laboratory blender for 2 min, and appropriate serial dilutions were prepared aseptically.

Reference halawet eljibn

Two samples were prepared at the Food Preparation Laboratory of the University of Jordan. The samples were prepared according to the traditional recipes commonly used in most bakeries and sweet shops where the commercial halawet eljibn samples were obtained. The dough was prepared with 750 ml of water, 125 g of sugar, 600 g of white unsalted cheese, and 375 g of fine semolina and seasoned with 125 ml of rose water. The filling cream was prepared with 2 L of whole milk, 1 L of liquid cream, 500 ml of vinegar, 30 g of starch, 30 g of fine semolina, 30 g of sugar, 30 ml of rose water, and 15 g of butter. The dough ingredients were combined in a non-stick pan, rose water was added just before the mixture reached boiling point, left to boil for 15 min and transferred to a tray. The filling cream was prepared by heating the milk and liquid cream in a deep pot, adding the vinegar, sieving it to remove water and whey protein, resulting in a solid mixture which was then transferred to a sterile glass bowl. The ingredients containing starch, semolina, sugar, rose water, and butter were added immediately to the mixture. The dough was subsequently shaped into thin sheets, filled with the cream mixture, and rolled using a nylon wrap. The prepared samples were subsequently evaluated for their chemical and microbiological properties using methods consistent with the evaluation of commercial samples to identify any potential food safety concerns.

Statistical analysis

Statistical analysis was performed using SAS, with the analysis of variance (ANOVA) method, at a significance level of 0.05%, to determine the significant differences between treatments. The experiments were conducted in two separate intervals.

Results

Chemical examination of halawet eljibn

-Moisture content analysis

The moisture content of the market samples collected in interval I was found to have a mean average of 45.7%. On the other hand, the mean average moisture content of the market samples collected in interval II was found to be 45.3%. The reference halawet eljbin sample was found to have a moisture content of 44.92%. The obtained results from the analysis of the market samples in interval I and interval II were significantly different (p<0.05) (Table 1). These results indicate that the moisture content of halawet eljbin may vary between different intervals.

-pH analysis

The mean average pH of halawet eljibin market samples was 6.3 in interval I and 6.4 in interval II. The results showed a significant difference between the two intervals (p<0.05). Generally, the pH of halawet eljibin market samples was found to be higher than 6 (Table 1) considering as a suitable range for the growth of various pathogenic microorganisms, mainly *S. aureus*.

-Titratable acidity analysis

A significant difference observed between the titratable acidity (as lactic acid) of halawet eljibin market samples and reference samples. The mean average titratable acidity of market samples was found to be 0.28%, while reference samples exhibited an acidity level of 0.24%. Furthermore, a statistically significant difference (p<0.05) was observed in the titratable acidity levels of halawet eljibin samples collected during interval I and interval II.

Microbiological Examination of Halawt Eljibn

-APC

The APC of halawet eljibn samples collected in interval I and II exhibited a range of 4.8 to 8.2 log Colony Forming Unit (CFU)/g. The APC in interval I (October 2021) was higher, with an average of 7.2 log CFU/g, compared to 6.2 log CFU/g in interval II (December 2021). The APC of reference halawet eljibn samples was significantly lower (p<0.05), at 2.3 log CFU/g (Figure 1).

-Coliform count

A significant difference (p<0.05) was observed in the coliform counts of halawet eljibn market samples collected during intervals I and II when compared to the reference sample. Specifically, the reference sample exhibited an average coliform count of not detected, while the average counts in market samples in intervals I and II were 4.4 and 3.8 log CFU/g, respectively. This suggests that the

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coliform count in market samples was significantly higher (p<0.05) than that of the reference samples. Additionally, a significant difference (p<0.05) in coliform count was observed between samples collected during the first interval (October 2021) and those collected during the second interval (December 2021) (Figure 1).

-LAB count

The LAB for interval I ranged from 6.6 to 8.7 log CFU/g with an average of 7.4 log CFU/g. For interval II, the LAB ranged from 5.2 to 7.6 log CFU/g with an average of 6.3 log CFU/g. A significant difference (p<0.05) was noticed between market samples and reference halawet eljibn prepared in the laboratory and used as a comparison control, which had a LAB of 1.6 log CFU/g (Figure 1). The majority of the samples had significantly higher (p<0.05) LAB during interval I compared to interval II, with an average of 7.4 log CFU/g in interval I and 6.6 log CFU/g in interval II. To verify the presence of LAB, a catalase test was conducted on all market and reference samples of halawet eljibn. The test, as described in the FDA bacteriological analytical manual, involved the addition of 3% H_2O_2 drops to the samples. Results indicated that all samples were catalase-negative, Gram positive, non-spore forming rods.

-S. aureus count

The *S. aureus* count for interval I ranged from 1.5 to 3.5 log CFU/g with an average of 2.3 log CFU/g. In contrast, the *S. aureus* count for interval II ranged from 1.0 to 3.0 log CFU/g with an average of 1.8 log CFU/g. In both intervals, the *S. aureus* ranged from 1.0 to 3.5 log CFU/g, with an overall average of 2.0 log CFU/g. The majority of market samples displayed a significant higher differences (p<0.05) in counts in interval I as compared to interval II. These findings were consistent with the *S. aureus* results of the reference halawet eljibn samples prepared in laboratory and utilized as a comparative control, and yielded no detection (Figure 1). The results of coagulase test indicated that all tested market samples were coagulase positive, while none of the reference samples were positive. The majority of the market samples demonstrated clotting within 2-5 h of incubation at 37 °C under continuous monitoring.

-Yeast and mold count

Yeast and mold count for market samples in interval I ranged from 2.3 to 4.6 log CFU/g, with an average of 3.6 log CFU/g, while the yeast and mold count for interval II ranged from 2.0 to 3.8 log CFU/g, with an average of 2.9 log CFU/g. The overall range of yeast and mold count for both intervals was between 2.0 to 4.6 log CFU/g, with an average of 3.2 log CFU/g. A significant difference (p<0.05) noticed in yeast and mold counts in interval I as compared to interval II with a noticeable higher counts. Moreover, a significant difference (p<0.05) in yeast and mold count was discerned between reference halawet eljibn (Figure 1).

Table 1: Averages of moisture, pH, and titratable acidity of halawet eljibn samples collected from different sweet shops in Amman, Jordan, and reference samples prepared under hygienic conditions.

Sweet shops	Moisture (%)		pH		% Titratable acidity (as lactic acid)	
	Interval I (mean±SD)	Interval II (mean±SD)	Interval I (mean±SD)	Interval II (mean±SD)	Interval I (mean±SD)	Interval II (mean±SD)
1	44.685±0.104 ^{ABC}	46.18±0.1589 ^{ABCD}	6.32±0.000484 ^{BCDE}	6.415±0.000169 ^{ABCDEF}	0.305±0.000249 ^{A}	0.335±0.000004 ^{A}
2	43.04±0.065 ^{C}	43.38±0.584 ^{BCD}	6.48±0.001600 ^{ABCD}	6.425±0.0025 ^{ABCDEF}	0.365±0.003609 ^{A}	0.295±0.000004 ^{AB}
3	45.665±0.237 ^{ABC}	46.48±0.0934 ^{ABCD}	6.25±0.006256 ^{CDE}	6.325±0.001664 ^{DEFG}	0.27±0.000081 ^{A}	0.235±0.000081 ^{AB}
4	43.27±0.039 ^{C}	42.685±0.522 ^{D}	6.105±0.026009 ^{E}	6.2±0.0004 ^{FG}	0.345±0.001225 ^{A}	0.285±0.000004 ^{AB}
5	44.455±0.028 ^{BC}	43.175±0.216 ^{CD}	6.405±0.000025 ^{ABCD}	6.355±0.000064 ^{CDEFG}	0.32±0.000484 ^{A}	0.275±0.000004 ^{AB}
6	44.32±0.104 ^{BC}	45.06±0.253 ^{ABCD}	6.555±0.0025 ^{AB}	6.575±0.0009 ^{ABC}	0.18±0.014489 ^{A}	0.2±0.000009 ^{B}
7	46.53±0.282 ^{ABC}	47.63±0.320 ^{ABAC}	6.385±0.000025 ^{ABCD}	6.385±0.000025 ^{BCDEFG}	0.275±0.000009 ^{A}	0.285±0.000004 ^{AB}
8	49.21±0.140 ^{A}	44.36±1.052 ^{ABCD}	5.805±0.2704 ^{F}	6.17±0.014449 ^{G}	0.26±0.002569 ^{A}	0.34±0.019681 ^{A}
9	46.75±0.096 ^{ABC}	44.79±0.375 ^{ABCD}	6.09±0.0324 ^{E}	6.275±0.0064 ^{EFG}	0.275±0.000009 ^{A}	0.23±0.000961 ^{AB}
10	43.55±0.854 ^{BC}	48.18±0.481 ^{A}	6.6±0.0025 ^{A}	6.545±0.000121 ^{ABCD}	0.24±0.003609 ^{A}	0.265±0.000004 ^{AB}
11	46.2±0.050 ^{ABC}	46.73±0.234 ^{ABCD}	6.495±0.000409 ^{ABC}	6.6±0.001296 ^{AB}	0.29±0.000289 ^{A}	0.235±0.000961 ^{AB}
12	47.95±0.124 ^{AB}	45.38±0.702 ^{ABCD}	6.225±0.0121 ^{DE}	6.49±0.000121 ^{ABCDE}	0.3±0.000009 ^{A}	0.315±0.001681 ^{AB}
13	47.95±0.124 ^{AB}	42.9±0.556 ^{D}	6.27±0.0009 ^{CDE}	6.3±0.0009 ^{EFG}	0.265±0.000009 ^{A}	0.305±0.000004 ^{AB}
14	46.1±0.029 ^{ABC}	44.86±0.208 ^{ABCD}	6.29±0.108900 ^{CDE}	6.625±0.1369 ^{A}	0.315±0.000225 ^{A}	0.33±0.000025 ^{A}
15	46.7±0.604 ^{ABC}	47.635±0.361 ^{AB}	6.24±0.0016 ^{CDE}	6.36±0.000049 ^{CDEFG}	0.25±0.000961 ^{A}	0.345±0.017649 ^{A}
Reference samples	44.06±0.082^{AB}	45.78±0.63 ^{AC}	6.32±0.000047 ^{BCD}	6.32±0.00088 ^{ABC}	0.23±0.00371 ^{A}	0.25±0.002104 ^{A}

Data in same column with different letters are significantly different (p<0.05)

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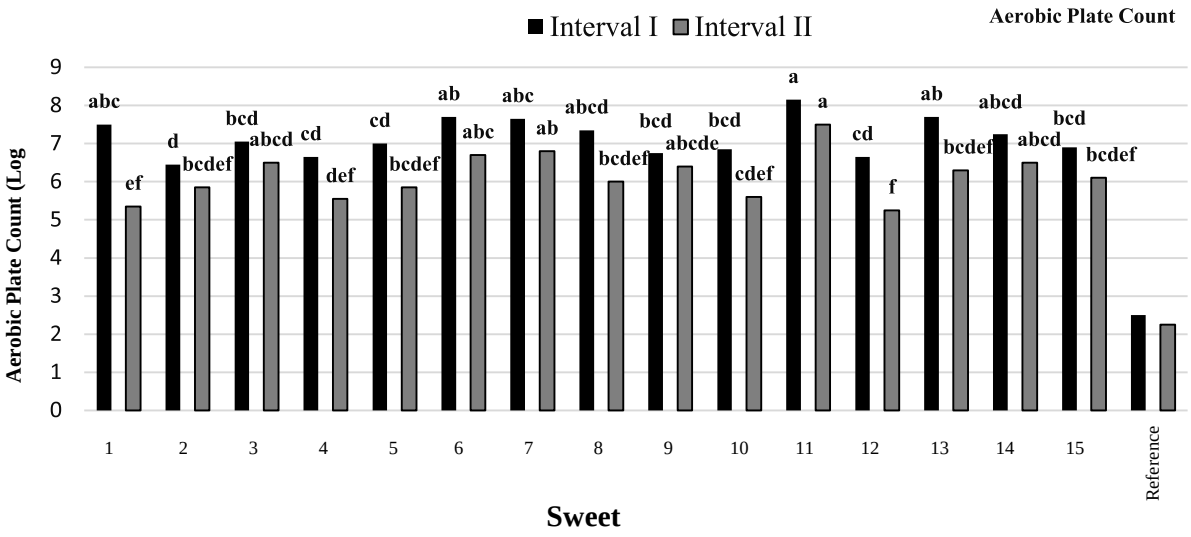

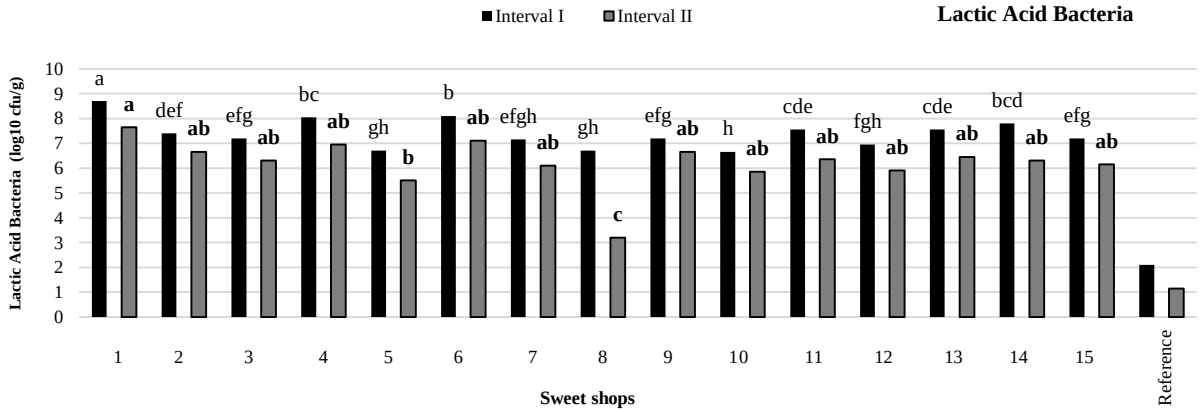

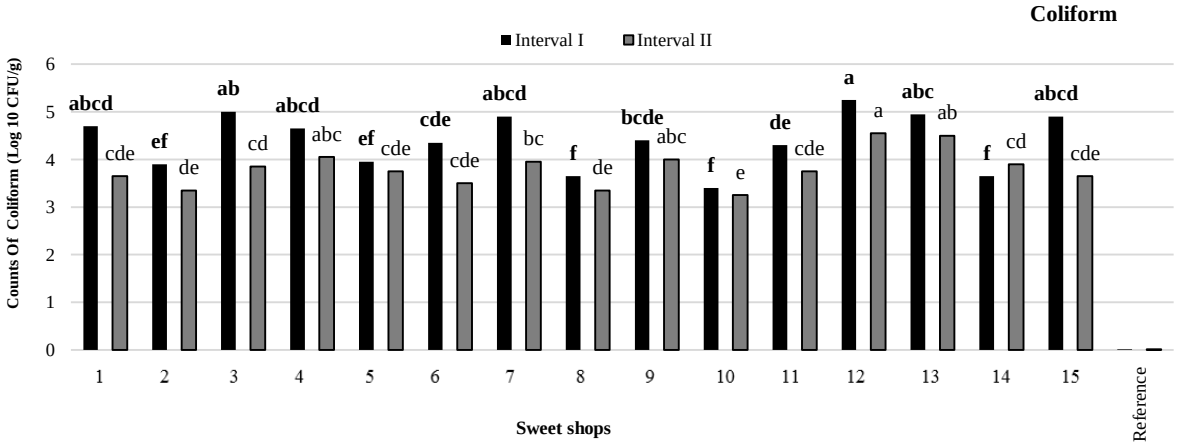

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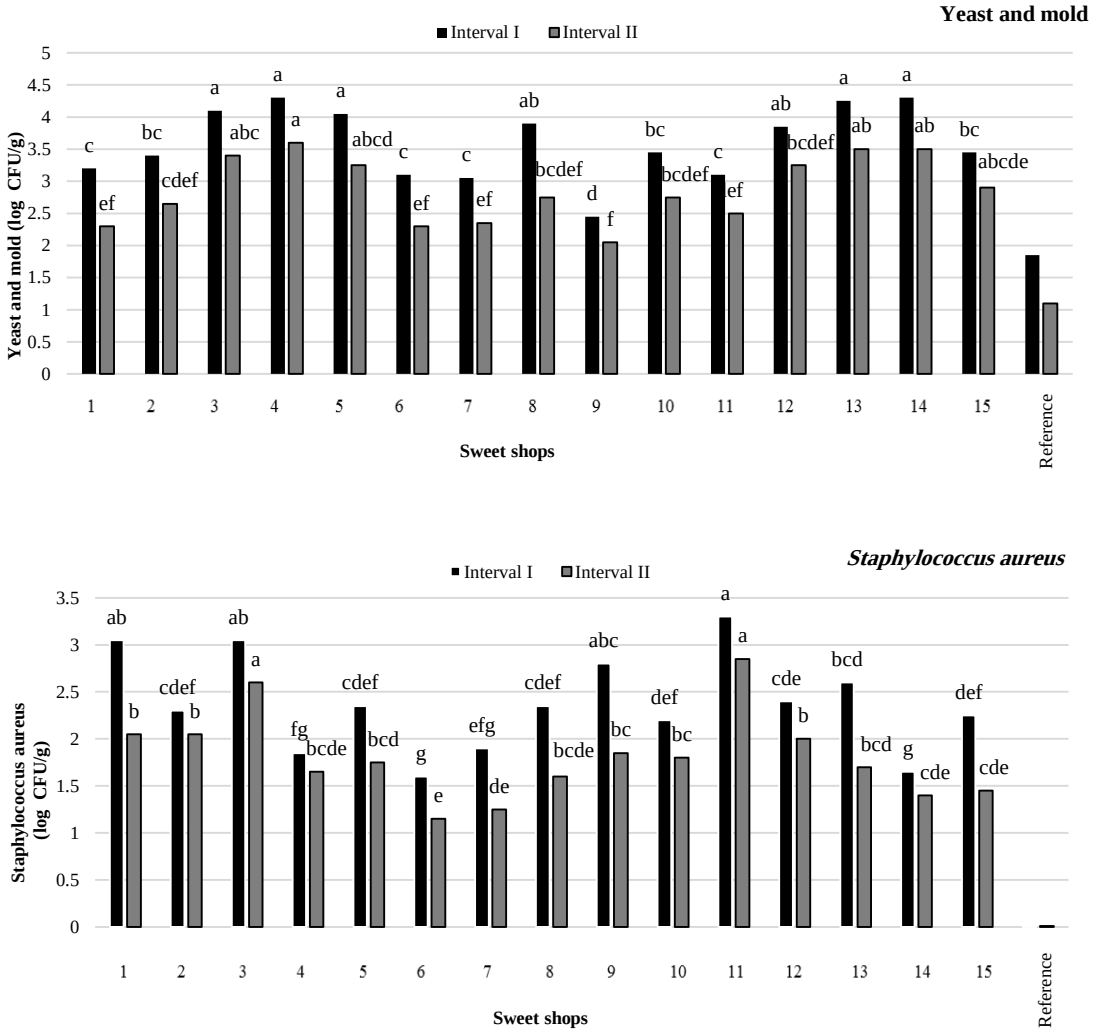

Figure 1: Aerobic Plate Count (APC), counts of coliforms, Lactic Acid Bacteria (LAB), *Staphylococcus aureus*, and yeasts and molds of halawet eljibn samples collected at two intervals from different sweet shops in Amman, Jordan. Figures with different letters indicate significant differences (p<0.05)
CFU=Colony Forming Unit

Discussion

The results of this study indicated that the halawet eljibn samples had moderate moisture content. Although the water activity (a_w) was not directly measured in this study, it is known that halawet eljibn has a moderate moisture level providing a suitable environment for the growth of various microorganisms such as LAB, *Lactobacillus*, and *Leuconostoc* that can tolerate low to moderate a_w (Mataragas et al., 2003). On the other hand, *S. aureus*, a potential pathogen, has a unique resistance to low a_w environments and can grow over a wide range of a_w values, from 0.83 to >0.99 (Bremer et al., 2004). Hoteit et al. (2021) conducted a study on food exchange systems based on the most consumed Arabic sweets and reported that the moisture content in halawet eljibn samples was 45.4%, which is consistent with the results of this research.

The pH of halawet eljibn samples in this study was found to be higher than 6 (Table 1), which is considered to be suitable for the growth of various pathogenic microorganisms, particularly *S. aureus*. This status is due to the composition of halawet eljibn, including cheese and cream filling, which are favorable for *S. aureus* growth. *S. aureus* is able to survive well in food stored below -20 °C and has the ability to grow in a wide pH range of 4-10, with an optimum pH range of 6-7 (FSANZ, 2013; Stewart, 2003). The favorable pH levels in halawet eljibn samples and the presence of cheese and cream filling create an ideal environment for *S. aureus* growth, which can pose a potential health risk to consumers in case improperly managed.

The presence of LAB in halawet eljibn samples can ferment the sugars present in the mixture, leading to the

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production of lactic acid and contributing to the acidity and flavor of the final product. Furthermore, the pH levels in halawet eljibn samples encourage the growth of yeast and mold, which can ferment the sugars present in the mixture and produce ethanol and carbon dioxide, thereby contributing to the texture and flavor of the final product. However, the presence of molds can lead to spoilage of the final product by producing off-flavors and mycotoxins (Faria-Oliveira et al., 2015).

The APC is a widely recognized method for assessing the microbiological quality of food products. It quantifies the presence of aerobic microorganisms in a sample and is valued for its simplicity and speed (Mendonca et al., 2020). In this study, elevated APC values suggest exposure to suboptimal hygienic conditions during various stages, such as processing, storage, and transportation, posing potential health risks. Monitoring APC is essential for ensuring food safety. Several factors influence APC, including product type, ingredients, and preservation methods. Products with high water activity and nutrient content are more conducive to microbial growth, resulting in higher APC. Additionally, storage and transportation temperature play a role, with proper refrigeration inhibiting microbial growth and reducing APC (Knutson, 2020).

A study by Aydin et al. (2009) investigated the microbial content of two traditional Turkish sweets, Hosmerim and cheese Halva, which are primarily made from cheese and semolina. The study illustrated that cheese Halva samples had high levels of mesophilic aerobes, with a mean count of 5 log CFU/g. Similarly, Hosmerim samples were found to have high levels of mesophilic aerobes, with a mean count of 4.8 log CFU/g. In an identical investigation by Christelle et al. (2021), samples of dêguê, a traditional kind of pudding based on semolina and milk, collected from local markets in Côte d'Ivoire had high levels of mesophilic aerobes. These result potentially due to improper handling and storage. In a comprehensive study by Odeh and Yamani (2019), the chemical and microbiological quality of Baloryeh, Burma, and Baklawa, popular Arabic sweets in Amman, Jordan, was assessed. The results showed that the APC values in these samples were relatively low, exhibiting minimal variation among different brands and between samples obtained from sweet plants and the market. However, Baklawa samples from the market displayed the highest APC values, with an average of 4.9 log CFU/g. Furthermore, Baklawa samples from the market exhibited the highest coliform counts, reaching up to 550 Most Probable Number (MPN)/g.

Coliforms are commonly used as an indicator of sanitary quality in food products, as they are a marker of potential fecal contamination. High coliform counts in food samples may indicate poor hygienic conditions during processing, storage or transportation, and may pose a risk to human health (Martin et al., 2023). In this study, the coliform count of halawet eljibn samples found to be elevated. Possible causes for the high coliform count in halawet eljibn samples may include the use of water sources contaminated with fecal matter during preparation and cleaning processes as well as inadequate sanitation and personal hygiene practices among handlers. Additionally, the rich and moist nature of the halawet eljibn dough, which contains white cheese, may provide an ideal environment for the growth of coliforms and other microorganisms.

In other study by Khalifa and Dowidar (2022) on different sweets in Aswan, Egypt, coliforms were found in a significant portion of Belillah, custard, and Om-Ali samples analyzed. Specifically, the coliform count in Belillah samples was the highest, ranging from 1.5 to 3 log CFU/g, followed by custard (1.0 to 1.6 log CFU/g), and Om-Ali (1.0 to 1.5 log CFU/g) samples. Additionally, the study found that fecal coliforms were present in 36% of Belillah samples, 12% of custard samples and 12% of Om-Ali samples, with counts ranging from 1.7 to 2 log CFU/g, 1.5×10 to 1.1 log CFU/g, and 1.0 to 1.3 log CFU/g. These findings suggest poor hygienic practices during the manufacturing, handling, and storage of dairy sweets. Identical findings were reported in other studies including Sotohy et al. (2022) who conducted a study in El-Dakhla city, new Valley Governorate, Egypt, examining 150 samples of ice cream, rice pudding, and Mahlabia. The investigation determined average total coliform counts of 6.7 log CFU/g for ice cream, 6.8 log CFU/g for rice pudding, and 6.4 log CFU/ml for Mahlabia.

The high levels of LAB found in the samples of this study can be attributed to inadequate sanitation practices during preparation, storage, and refrigeration. Additionally, the nearly neutral pH and favorable moisture content of halawet eljibn (intrinsic factors) provide an ideal environment for the growth of LAB. In contrast, the low microbial counts in reference samples indicated that they were produced under strict hygienic conditions. These findings are consistent with previous research by Yamani and Al-Dababseh (1994) investigating that the LAB in fresh hoummos was significantly higher in the summer (1.6×10^8 CFU/g) in comparison with the winter (1.6×10^7 CFU/g). According to the Centre for Food Safety and Public Health of England, RTE food products should have LAB of less than 10^8 CFU/g in order to be considered microbiologically safe. Hence, halawet eljibn market samples fail to adhere to the microbial quality standards set by the Centre for Food Safety and Public Health of England (CFS, 2014). LAB have been shown to exert an inhibitory effect on the growth of certain food-borne pathogens, including *Listeria monocytogenes*, *S. aureus*, *Salmonella*, and *Escherichia coli* (Gao et al., 2019). This

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status bears a positive impact on food safety. The elevated counts of LAB observed in halawet eljibn samples in this study may contribute to a reduction in the growth of pathogens such as *S. aureus* by competing for nutrients. A study by Guldas et al. (2010) demonstrated that without the use of an edible coating, the LAB count in mustafakemalpasa Turkish sweet samples increased significantly, reaching 4.2 log CFU/g within 3 days of storage. This case highlights the potential for LAB to negatively impact the shelf life of this traditional sweet. The detection of *S. aureus* or its enterotoxins in food products or on food processing equipment is considered often as an indication of inadequate sanitation practices. Furthermore, the intrinsic characteristics of halawet eljibn, such as its pH of approximately 6, putting within the optimal range for *S. aureus* growth as reported by FSANZ (2013), may also contribute to the presence of this microorganism. The low counts of *S. aureus* in this study may be attributed to competition with LAB, as well as the lack of a final heat treatment step in the production of halawet eljibn, as *S. aureus* is heat-sensitive and it is resistant to freezing and survives well in food stored at refrigerator below -20 °C (FSANZ, 2013; Stewart, 2003). The European Commission has established guidelines for the presence of *S. aureus* and other coagulase-positive staphylococci in cheese and milk-based RTE foods, with the recommended limits not exceeding 10-10^5 CFU/g (EC, 2007). However, the Health Protection Agency (HPA) has set a slightly higher threshold, with a maximum limit of 10^5- <10^7 CFU/g for *S. aureus* in RTE foods (HPA, 2009). Based on the result of this study, halawet eljibn market samples exceeded these established guidelines, highlighting the need stricter control measures to ensure the safety and quality of these products for consumers. In a study conducted in Brazil on handmade sweets, 6 out of 50 samples (12%) were found to be contaminated with Coagulase-Positive Staphylococci (CPS). Molecular analysis confirmed that all isolates were identified as *S. aureus*, as evidenced by the amplification of a 252 bp fragment related to 16S rRNA specific to the *Staphylococcus* genus (Kroning et al., 2016). In another study conducted on milk-based sweet products in Pakistan, a total of 290 samples of Khoya (75), Qalaqand (75), Rabri (65), and Rusmalai (75) were analyzed for the presence of *S. aureus*. The results indicated that the total staphylococcal counts ranged from 1.5 to 4.6 log CFU/g in Khoya samples, 2.0 to 3.8 log CFU/g in Qalaqand samples, 3.1 to 4.5 log CFU/g in Rabri samples, and 3.1 to 3.6 log CFU/g in Rusmalai samples (Sahir et al., 2013). Cokal et al. (2012) investigated the presence of *S. aureus* in Turkish traditional foods, specifically mihalic cheese and hosmerim sweet. The study found that 64% of the 200 samples tested were contaminated with *S. aureus*, with levels ranging from 1.0 to 3.3 log CFU/g. The researchers attributed the contamination to factors including tools, equipment, workers, as well as the environment.

The yeast and mold count in this study found to be elevated, The Public Health Laboratory Service Advisory Committee for Food and Dairy Products has established guidelines for the acceptable level of yeast and mold count in RTE foods, with a recommended limit of <10^2 CFU/g (Gilbert et al., 2000). Additionally, in a recent study conducted by Dağ (2020) to evaluate the microbiological quality of RTE foods in Turkey, the yeast and mold count was tested according to the standards outlined in the Turkish food codex microbiological criteria regulation supplementary document. According to these guidelines, a maximum limit of 1,000 CFU/g was recommended for yeast and mold in these foods.

The results of this study reveal that halawet eljibn market samples exceeded the established limit for yeast and mold count in RTE foods. This result emphasizes the significance of implementing stricter control measures to decrease the level of yeast and mold count in halawet eljibn market samples, in order to ensure compliance with the safety requirements for RTE foods. In a study conducted by Güven and Demir (2010), it was found that the number of yeast and mold in samples of cheese halva sweets kept at room temperature for 15 days was <10^4 CFU/g. The same samples stored at refrigeratored temperature for 30 days had a yeast and mold count of <10^3 CFU/g. A study by Ronge et al. (2022) aimed to investigate the microbial parameters of Gulabjamun - Indian sweet- blended with coconut and wheat bran. The results revealed that yeast and mold count was nil in fresh samples of Gulabjamun, however, the count increased to 19.50 CFU/g after 28 days of refrigeration storage. As reported in a research conducted by Ali et al. (2022), their study on sweet-based dairy products revealed that the yeast and mold counts were highest in Burfi and Khoa, while Rusgullaha and Gulabjamun exhibited the lowest counts. The highest increase in yeast and mold count was found in Rusgullaha samples, with a 46.1% increase after storage. In a study conducted by Ismawati et al. (2019) on the storability of seaweed jelly candy, it was observed that the mold and yeast counts exceeded the maximum permissible limit of 10^3 CFU/ml after the second day of storage, rendering the candy unwholesome for consumption by day four.

Conclusion

This study found that halawet eljibn provides favorable conditions for bacterial growth due to its high moisture content, pH, and the use of cheese as a basic ingredient in its preparation. However, market samples of halawet eljibn were identified to be non-compliant with the Jordanian

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standards for traditional sweets as set by Jordanian Institute for Standards and Metrology (JISM), due to high levels of fecal coliforms and *S. aureus*. To ensure the microbiological safety of halawet eljibn, it is crucial to observe proper personal hygiene, washing, and disinfection practices during its preparation. Additionally, maintaining halawet eljibn at refrigerated temperatures and consuming it promptly after preparation can aid in limiting the proliferation of microorganisms. Furthermore, the preparation of halawet eljibn in smaller quantities and the storage in separate containers can prevent cross-contamination and decrease the microbial load at the time of consumption.

Author contributions

The study was designed by M.I.Y.; M.B.A.-H. collected the samples, conducted the experiments, and wrote the manuscript. Both authors have critically reviewed and endorsed the final manuscript version.

Conflicts of interest

The authors declare that there is no conflict of interest.

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