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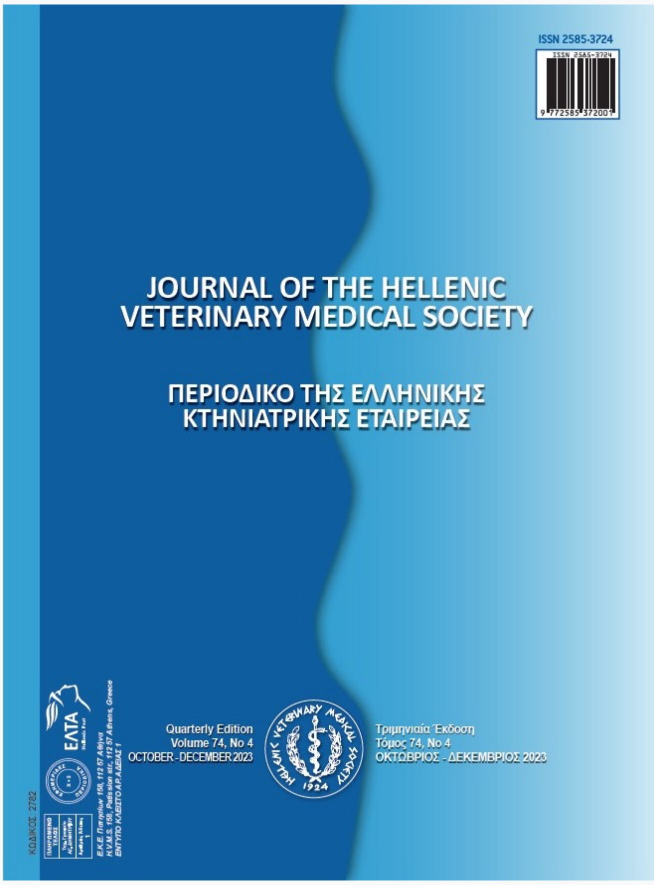

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Microbiological quality of some commercial dairy products and cheese analogues focused on Mideast

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ABSTRACT: Dairy products are food consumed by people of all age groups, especially children. They are highly nutritious and provide micro and macro-nutrients essential for the growth and maintenance of human health. However, they are not only nutritious for humans;but also good growth substrates for microorganisms. Owing to insufficient animal health control, inadequate training of farmers and dairy processing workers about dairy hygiene, and weakness in the cold chain during production and storage, milk and dairy products are considered a vulnerable category for potential microbial contamination. This review is considered a discrete review aimed to show the degree of microbiological quality of some varieties of dairy and non-dairy products, fermented milk, dairy cheeses, and cheese analogues, predominately in the Mideast.

Keywords: Microbiological quality; fermented milk; dairy cheeses; cheese analogues; microbial contamination

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INTRODUCTION

Microbiological hazards are ranked as the most well-known public health concern in milk derivatives, followed by chemical and physical hazards. Various stages of production are incriminated in microbial contamination. The contamination may occur post-pasteurization as a result of adding soiled ingredients or poor handling of the finished goods, elevated storage temperature, and defective packaging operation (Van Asselt et al., 2017). Not only deteriorating bacteria; but also pathogenic could be detected in dairy foods, in particular,*Bacillus cereus* (*B. cereus*), *Staphylococcus aureus* (*S. aureus*),*Escherichia coli (E. coli) O157:H7*, *Salmonella* spp, and *Listeria monocytogenes* (*L. monocytogenes*). Milk-borne epidemics have been linked to these bacterial species (Sulaimanand Hsieh, 2017).

Food safety is an imperative concern for authorities, food manufacturers, merchants, and consumers globally; this heightened level of urgency is remarkable in the dairy business in Middle East countries (Chavarríaet al.,2015).Consumption of cheese is gradually increasing in the consumer market and food processing industry. The arrangement of African countries that consumed cheeses in 2021 was demonstrated in Table 1. Domestic cheese manufacturers are more focused on developing different products leading to an increase in production. It is considered a good source of protein and minerals (such as calcium and phosphorus) that have nutritional value (Hajikhani et al., 2021).

Statista (2022)

Fermented dairy products have been around for thousands of years and played an important part in the human diet; that constitutes a significant component of nutrition. Various countries around the world produce a wide variety of fermented milk products, and around 400 names are applied to traditional and industrially made fermented milk products, classified based on the methods of fermentation or processing related to the microorganisms involved (Jingkai et al., 2020; Xiao and Li, 2022).In recent years, as people are becoming more aware of the link between food and health, interest in the beneficial health effects of functional food has increased around the world (Heydariet al.,2021).

Usually, sterile conditions or milk are not used in the production of fermented dairy products, which might provide access to pathogenic or non-starter microorganisms in the fermenting food system (Hickey et al.,2015). The World Health Organization Eastern Mediterranean region, which includes the Middle East and North Africa, is believed to have the third-greatest incidence of foodborne illnesses, following Africa and Southeast Asia. The WHO estimates that over one hundred million individuals in this region contract a foodborne illness each year, with 32 million of those patients being children under the age of five years old (WHO, 2015).

Kariesh cheese

One of the most widely known soft cheeses in Egypt is Kariesh. It is produced from skimmed cow and buffalo milk or buttermilk from sour cream depending on the acid coagulation of milk. It is deemed to be one of the most substantial conventional Egyptian milk products;it is frequently produced in rural areas and the countryside, particularly in small communities(Todaro et al., 2013).

The microbial load of Kariesh cheese is deter-

Table 1. Arrangement of African and some Mideast countries consumed cheeses in2 021.

Country	Percentage	Country	Percentage
South Africa	48.00	Togo	15.00
Morocco	44.00	Guinea	14.00
Egypt	32.00	Ethiopia	13.00
Namibia	30.00	Angola andZimbabwa	12.00
Botswana	29.00	Mali	11.00
Madagascar	28.00	Cameroon and Ghana	9.00
Senegal	24.00	Tanzania	8.00
Gabon	22.00	Kenya and Uganda	7.00
Congo	21.00	Nigeria	7.00
Benin	18.00	Zambia	7.00

mined by several factors, including the quality of raw milk, heat treatment, transportation temperature, and storage conditions. Moreover, the poor personal hygiene of Kariesh handlers and the presence of flies and insects are potential sources of contamination (Hawazen et al., 2016).*S. aureus* is one of the most prevalent bacteria linked to food borne illnesses related to dairy products, particularly raw-milk cheese (Techer et al., 2013). In Kariesh cheese production, *E. coli* serves as a hygienic indicator bacterium, indicating faecal contamination. These bacteria are classified into several categories based on their virulence factors and phenotypic features, such as enterohaemorrhagic *E.coli* (EHEC), enteropathogenic *E.coli* (EPEC), etc. Foodborne illness outbreaks are caused by the *E. coli O157:H7* serotype all over the world (Law et al., 2017; Govaris et al., 2018).

Ibrahim et al.(2015) evaluated the microbial load of 30 Kareish cheese samples collected from the Cairo governorate. The mean counts of *S.aureus,* coliforms group, and yeasts & moulds were 5.3, 5.8, and 5.5 logs CFU/g, respectively. The microbiological quality of Kariesh cheese was evaluated by Hassan and Gomaa (2016),who examined one hundred Kariesh samples obtained from various supermarkets and retailer shops (50 from Cairo and 50 from Giza). The mean value of *S. aureus*, coliforms, and total yeast & mould counts were $1.8\times10^4 \pm 3.5\times10^3$ & $8.7\times10^4 \pm 2.5\times10^4$; $6.1\times10^5 \pm 3.5\times10^5$ & $5.8\times10^5 \pm 2\times10^5$, and $5.8\times10^5 \pm 2\times10^5$ & $3.1\times10^5 \pm 4.3\times10^4$ CFU/g in Kareish cheese from Cairo and Giza, respectively. *B. cereus* and *E. coli* were detected in 20%and 18% in Cairo samples and in 30%and 28% in Giza samples, while *Salmonella* spp. was absent in all examined samples.

Kamal et al. (2017) analyzed 30 Kareish cheese samples collected from Alexandria Governorate and revealed that the prevalence of coliforms, *S.aureus,* and mould were 75%, 55, and 53% with mean values of 5.49 ± 0.62, 4.42 ± 0.89, and 4.49 ± 0.31 CFU/g with 25%, 45%, and 65% compliance with the Egyptian Standards, respectively. *Salmonella* spp. could not be detected in all the examined samples.

Omar et al. (2018) analyzed twenty-five samples of Kariesh cheese purchased from small private dairy farms, small shops, and street vendors in Mansoura, Egypt, between April and October 2015 and found that *Salmonella* was present in a percentage of 8% (2/25 samples) of the examined samples. Adam et al.(2021) recorded the highest % (78.0) of fungi in the examined fifty Kareish cheese samples that were collected from El Fayoum Governorate, Egypt between November 2019 and January 2021 with a mean value of 1.7×10^6 Log CFU/g. Coagulase Positive Staphylococci and coliforms were found in 20.0%and 88.0% with mean values of 6.6×10^5 and 4.1×10^4 Log CFU/g, respectively. The most aerobic spore formers identified as *Bacillus licheniformis* with 23.7%.The *nhe* gene of *B.cereus* was the most found in all the investigated samples. *E. coli, Salmonella* spp.,and *P. aeruginosa* were absent in all samples.

Soft cheese

Soft cheese is one of the most popular, delicious, highly nutritional and healthy dairy products in Egypt (Farrag et al., 2020).Owing to the physicochemical and combative characteristics of lactic acid bacteria, cheese is generally perceived as a safe product; nevertheless, it could be a significant contributor to food-borne illnesses if polluted. In earlier decades, *Salmonella* spp., *S. aureus*, and *E. coliO157:H7* were identified as the most prevalent food-borne pathogens that cause illnesses related to cheese (Cokal et al., 2012).Due to their high moisture content, soft and semisoft cheeses promote the growth of many pathogens. These cheeses provide a concern for *L. monocytogenes* since it can multiply while being stored in the refrigerator (European Food Safety Authority, EFSA, 2015). The most common sources associated with cheese contamination are demonstrated in Fig. 1.

According to Temelli et al. (2006), the average results of the microbiological analysis of brined Turkish soft white cheese were 6.1, 3.1, 3.9, and 2.9 log CFU/g for total mesophilic bacteria, Enterobacteriaceae, Staphylococci, and yeast & mold count, respectively. Brined cheese had mean concentrations of coliforms, *S. aureus*, molds, and yeasts of 4.1×10^2, 4.5×10^3, 4.5×10^3 and 9.2×10^4CFU/g, respectively (Mirazaei et al., 2008). Additionally, 58.4, 62.9, and 18% of the samples were found to contain *E. coli*, faecal coliforms, and positive coagulase *S. aureus*, respectively. However, two (6.66%) of the thirty samples included Salmonella.

El-Sayed et al. (2011) discovered that samples of the Domiati and Tallaga cheese varieties had the worst microbiological quality and the highest aerobic colony bacterial counts, with a maximum level of (10^{12}) CFU/g and an average of 10^7 CFU/g. While this was going on acid coagulation variety of Kariesh cheese displayed a greater fungus count and the lowest mycological quality with an average of 3×10^4CFU/g.

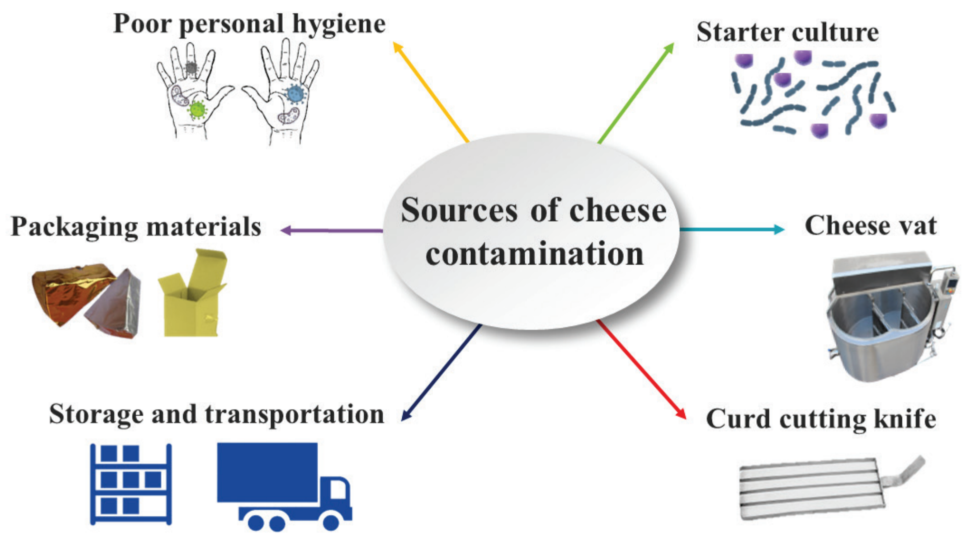

Figure 1. Most common sources associated with cheese contamination.

Only 3% and 7% of the samples from the Domiati and Tallaga cheese varieties contained Salmonella spp., respectively. Samples of soft cheese taken from Tammoun, Palestine, had an average total bacterial count of log 7.7 CFU/g. The fungi count increased, whereas the total bacterial count, coliforms, *E. coli*, *S. aureus*, and psychrotrophic bacterial counts significantly (p<0.05) dropped throughout the storage.

Ibrahim et al. (2015) evaluated the microbial load of 50 Domiaticheeses collected from the Cairo governorate. The average counts of *S.aureus,* coliform group, and yeasts & moulds were 4.4, 3.6, and 3.3 Log CFU/g, respectively. *E. coli* and *Salmonella* spp. were detected in (10/20) 20% and (2/20) 4% of the examined cheese samples, while *B. cereus* failed to be detected. Kummelet al.(2016) mentioned that pathogens in soft cheese could originate from humans or biofilms, possibly from inadequate acidification during cheese manufacturing. Generally, EFSA (2016) mentioned that >10^4*B.cereus*cells/ g cheese resulted in diarrheal toxins production in the people's gastrointestinal tract.

Haddad and Yamani (2017) found that coagulase-positive staphylococci count ranged between 5-8 log CFU/g and the mean values of total yeast & mould count was 3 Log CFU/g in 30 soft cheese samples gathered from production sites and shops in main Governorates of Jordan. *Salmonella* spp. was found in three cheese samples of the Madaba and Amman governorates. Kamal et al.(2017) analyzed 30 Domiatisoft cheese samples collected from Alexandria Governorate and revealed that the prevalence of coli forms, *S. aureus,* and moulds were 20%, 83.3%, and 46.7% and mean values of 4.10±0.15,4.94±0.61,and4.26±0.26logCFU/g,with80%,16.7%,and53.3% in compliance with the (ES, 2020), respectively. *Salmonella* spp. could not be detected in all the examined samples.

El-Ziney (2018) evaluated the microbial quality and safety of 21 soft cheese samples (9 Domiati, 4 Akkawi, 4 Halloumi, and 4 Nabulsi) collected from the Qassim market, Saudi Arabia. *E. coli* existed in a percentage of 14.28%, but *Salmonella* spp. and *L. monocytogenes* failed to be detected in all the examined samples.Fifty soft cheese samples were purchased by Omar et al.(2018) from small private dairy farms, small shops, and street vendors in Mansoura, Egypt between April and October 2015, *Salmonella* spp. prevalence was 20% (5/25 samples) in fresh soft cheese.On the other hand, the 25 pickled white cheeses were free from *Salmonella* spp.

Kirdaret al.(2018) reported that on day one of unpasteurized milk cheese ripening, yeast count was 5.47 log CFU/g, then their counts elevated during ripening, till the 60thday (7.2 log CFU/g) and following the count declined (6.64 log CFU/g). Whereas; maturation time had a significant (p<0.05) influence on the mould count, that increased during the 90 days of ripening. Although a low pH is not ideal for the growth of many deteriorating bacteria, it can promote the growth of mould and yeasts. The coliforms count (log CFU/g) was 3.28±1.13 on the first day and declined to 1.99±0 on the 60thand 90thdays. *E. coli*and coagulase-positive staphylococci failed to be detected.

Al-Gamalet al.(2019) revealed that the mean counts of aerobic spore formers, staphylococci count,coliforms, yeast, and mould counts were2.4±0.83&3.40.72,3.6±1.86&5.8±1.77,0.3±0.47 & 2.5±0.80, 4.2±2.48 & 2.05±1.44, and 2±1.43 & 1.1±0.73 Log CFU/g,respectively in15 Domiati and 15 Tallaga cheese samples collected from retail markets in three different Egyptian provinces (Cairo, Giza, and Menofia). The prevalence of *B.cereus, E. coli, Salmonella enteric* ,and *Pseudomonas aeruginosa* (*P. aeruginosa*) in Domiati and Tallaga cheese samples were 13.3 & 0%, 13.3&26.7%, 6.7& 0%, and 6.7& 0%, respectively. On the contrary, the mean count of staphylococci was 1.6±1.06 Log CFU/g. While aerobic spore formers, coliforms, yeast, and mould failed to be detected, as well as *E. coli, B. cereus, S. enterica*, and *P. aeruginosa* could not be found in the examined 15 Feta cheese samples.

Biolcati et al. (2022) studied the bacterial and fungal composition of soft cheese and found a possible association between its composition and the dairy environment, region, season, and raw materials quality utilized for production. Adam et al.(2021)stated that Coagulase Positive Staphylococci and coliforms were found in 20.0%and 76.0% of the examined 50 soft cheese samples that were collected from El Fayoum Governorate, Egypt between November 2019 and January 2021 with mean values of 4.3×10^4 and 1.4×10^3, respectively. The prevalence of *B. cereus* was 8.0%, and the isolates were tested for toxigenic genes by PCR, which proved to contain several enterotoxigenic genes that affect public health. The *nhe* gene was the most found in all the investigated samples. *E. coli*, *Salmonella* spp., and *P. aeruginosa* were absent in all samples.

In 2023, the microbiological analysis of 50 cheese samples (Akkawi) that were purchased from the retail markets in Lebanon revealed that *Staphylococcus aureus* was found in 32.0% of the examined samples in a count ranging from 1×10^2 to 2×10^5 CFU/g.*E. coli* was found in 80.0% of the examined samples in a count ranging from 1×10^3 to 2×10^7 CFU/g (Hussein et al., 2023).

Ras (Roumy) Cheese

Ras cheese is also known as Roumy cheese in Egypt and Arab nations. It is one of the most popular traditional hard cheeses in Egypt and the Mediterranean lands and parallels the Greek Kefalotyri cheese. Nevertheless, due to the potential for contamination with pathogenic or toxic microorganisms, remarkably bacteria, and fungi, they may be a threat to one health (Le Jeune and Rajala-Schultz, 2009; El-Fadaly et al., 2015). Because of the desirable fermentation processes in raw milk owing to the natural micro flora, raw Roumy cheese has higher and more pleasant tastes than pasteurized Roumy cheese (Hammamet al.,2020).

Recently, the new Egyptian standards for hard cheese, published by Organization for Standardization and quality control (ES, 2020), indicated that Ras cheese must be made from pasteurized milk. These standards aim to produce cheese under improved hygienic conditions, showing consistent and better quality. That means starter cultures should be added to pasteurized milk prior to the cheese being manufactured. Therefore, there is a great need for new starter cultures to use in the production of Ras cheese. Fadel and Ismail (2009) stated that the prevalence of *S.aureus*in 40 Ras cheese samples obtained from different markets in Ismailia City, Egypt, was (80%) with a mean count value of 5.54 log CFU/g. Both *E.coli* and *Salmonella* failed to be detected in the examined Ras cheese samples.

According to El-Kady et al. (2013), the total viable bacterial counts increased as the ripening period lengthened. In both fresh and ripened Ras cheese, the starter culture type at a rate of 1.0% significantly affected the total viable bacterial population, as well as the yeast and mold counts. Ras cheese containing *Lactococcuslactis sp. lactis* and *Lactococcuslactis sp. cremoris* had the highest total viable bacterial, yeasts and mould, spore-forming, and psychrophilic bacterial counts (7.75, 3.75, 3.95, and 4.58 CFU/g, respectively). The counts of the same parameters in Ras cheese with *Streptococcus thermophilis*, *Lactobacillus delbruckii sp. bulgaricus*, *Lactobacillus helveticus*, and *Lactobacillus casei* culture were the least significant.

Ombarak et al. (2016)investigated the prevalence of *E. coli* in Ras cheese collected from local markets, farmer vendors, and supermarkets at different localities in the Nile Delta region: Menofia and El Beheira Governorates, Egypt from April to November 2012. *E. coli* was found in 13/60 (21.7%) of the examined Ras cheese samples and *E. coli* carrying virulence genes were found in a percentage of 15.0%.El-Ziney (2018) evaluated the microbial quality and safety of seven hard cheese samples collected from the Qassim market, Saudi Arabia. None of the samples tested contained *E. coli* or *Salmonella* spp. (100.0% compliance with the European Regulation EC 2073/2005 and Gulf standards SO /FDS 1016 / 2014).A study carried out by Al-Gamalet al.(2019) investigated 15 Ras cheese samples collected from retail markets in three different Egyptian provinces (Cairo, Giza, and Menofia).The mean counts of aerobic spore formers, staphylococci count, coliforms, yeast, and mould count were3.7±1.06,6.5±1.07,2.1±1.41,4.5±1.96,and 2.4±1.69LogCFU/g, respectively. The prevalence of *E. coli* was 66.7%, while *B. cereus, S. enterica,* and *P. aeruginosa* were absent.

Abdeenet al.(2020)recorded that *B. cereus* was recovered with a percentage of 8.5% from Ras cheese from local markets in Menoufia Governorate, Egypt. The *nhe* gene was detected and dominated in all isolates 100.0%. The prevalence of *cytK* was (83.33%), while each of the *hbI, hblD, pc-plc*,and *ces* genes were recovered in 50.0% of tested isolates.

In one hundred Ras cheese samples harvested from various markets in El- Menoufia governorate, Egypt, 14 isolates of *B. cereus* accounted for 10% (10/100) of the analyzed samples. At least one full set of toxin genes either *nhe*or *hbl* was found in a significant proportion of *B. cereus* isolates from Ras cheese in 71.4% (10/14), and *CytK*was detected in 50% (7/14) of Ras cheese isolates, as reported by Hammad et al.(2021). Adam et al.(2021) recorded that the Coagulase Positive Staphylococci and coliforms were found in 22.0% and 86.0% with mean values of 4.6×10^5 and 3.1×10^3 Log CFU/gin the examined Ras cheeses collected from El Fayoum Governorate, Egypt, respectively. The *nhe* gene of *B.cereus* was the most found in all the investigated samples. *E. coli, Salmonella* spp.,and *P. aeruginosa* were absent in all samples.

Cheese Analogues

Dairy alternatives were once geared primarily toward consumers who actively avoided dairy due to allergy, intolerance, or a vegan diet. However, this is quickly changing due to emerging plant-based proteins and sensory quality advancements, coupled with concerns over environmental impacts, sustainability, health, and animal welfare, where more adults across dietary spectrums are choosing dairy substitutes (Short et al., 2021).In the dairy category plant-based; cheese substitutes (PBCS) saw the most growth in a year-over-year retail sales comparison increasing by 29% in 2020 in United States retail (Jeewanthi and Paik, 2020).

The cheese analogue was described as a new whey cheese, easy to process with enhancing health properties and excellent sensory parameters with prolonged preservation time. Whey cheeses are susceptible to microbial spoilage owing to contamination after heat processing of the whey had occurred. The cheese analogue on day one had less total colony count of 1.77 log cells/g and did not find coliforms on day 25 due to the polyethylene bag container of the whey blend before heating. So, by the end of cold storage, the conventional cheese spoiled, as pathogens were found in higher counts than those in the cheese analogue. This could be due to the various packaging methods for the investigated cheeses (Zoidou et al., 2016).

According to Hosny et al. (2011), adding aqueous curcumin extract (0.3%) to Karishcum cheese milk resulted in a reduction of bacteria counts by roughly one log for *Salmonella typhimurium*, two Log for *Pseudomonas aurogenosa*, and one log for *E. coli 0157:H7*, respectively. At the 14-day cold storage period, *S. aureus*, *B. cereus*, and *L. monocytogenes* all disappeared. The *E. coli* failed to be detected in all the examined flavoured cheese analogues and may be attributed to the starter cultures inhibition, competition for nutrients actions & areas of colonization, and vacuum packaging that reduces the oxygen concentration (Ganesan et al., 2012).

Ehsannia and Sanjabi (2016) evaluated the microbiological quality of cheeses analogues incorporated with *Bacillus coagulans* 10^8 cells/g during sixty-day cold storage. A decrease in water %, water activity, pH, and a significant improvement in the proteolytic activity of samples were gained by extended keeping time. The significant reduction of survival level of the probiotic cells was up to 1 month, while the total number of viable cells was elevated by extending storage time. A 20 and 67% elevation in coliforms and fungi count of the control sample were recorded after 2 months of fridge storage, respectively. A reduction in coliforms and fungi count was also found in the cheese analogues containing probiotics. Significantly, the spoilage chances were more happening in samples not containing the probiotic cells.Sallam et al. (2016) analyzed 120 randomly selected samples of locally produced processed cheese obtained from various stores in the governorates of Cairo, Giza, Alexandria, and Behara. Coliforms' mean value was 69.8±6.98 CFU/ g. *E. coli* O27wasisolated in three cheese samples.

Microbiological evaluation of Tallaga-like cheese manufactured in Damietta, Egypt revealed that the highest mean value of total viable bacterial number and fungi count were 3.51±0.01 and 2.69±0.11 log CFU/g, respectively. According to the findings, the total number of bacteria ranged from 3.11×10^{2}in cheese made with palm oil plus paprika after 30 days to 3.53×10^{2}in cheese made with palm oil alone and with palm oil plus cumin after one day. The lowest counts of mold and yeast (20) were found in cheese made with palm oil alone and cheese made with palm oil plus turmeric one month after production, while the highest counts (2.84×10) were found in cheese made with palm oil plus cumin one day after storage (Hamad et al., 2017).

Kamal et al. (2017) analyzed 30 plant-origin cheese samples collected from Alexandria Governorate, Egypt, and revealed that the prevalence of *S.aureus* and mould were 26.7% and 10%, with a mean value of 2.70 ± 0.62 and 1.20 ± 0.17 log CFU/g, respectively, and the samples were in compliance with (ES, 2005). On the other hand, coliforms and Salmonella could not be detected in the examined samples.

The microbiological of cheese analogue with cryo-powder was determined. The number of mesophilic aerobic and facultative-anaerobic microorganisms in samples was 2×10^{3} cells/g, and not revealed the Salmonella spp. So, the utilization of vegetable ingredients as bio-additives in the manufacturing process of cheese analogue is significant (Hachak et al., 2018).The highest count of psychographs in fresh cheese analogue with potato starch, palm oil, and wheat germ and after ten days of storage at 7°C was 2.5±0.2 and 2.8±0.17 log CFU/g, respectively, while fungi count could not be detected in any of the examined samples (Hussein and Shalaby, 2018).

Adam et al.(2021) recorded that. *B. cereus* was found in 2.0% of the examined 50 cheese analogue samples with a mean count of 3.7×10 Log CFU/g. *E. coli, Salmonella* spp.,and *P. aeruginosa* were absent in all the examined samples. During the three-month ripening period, the counts of yeast, molds, and coliforms increased in Ras cheese analogs (Habliza et al., 2022). According to El-Fadaly et al. (2015), these outcomes may be caused by a rise in moisture content, which in turn increases water activity and promotes microbial development, as well as a decrease in oxygen penetration, which favors the growth of lactic acid bacteria.

Yoghurt (zabadi) and drinking yogurt

Yoghurt is a functional dairy product consumed worldwide due to its positive effect on human health. However, if the selection of raw materials is not well controlled, good production practices are not used, especially in small-scale production, or if storage conditions are unfavorable, yoghurt spoils quickly, producing an unpalatable product for customers because of its yeasty and fermented flavor. Even though yeasts are primarily known as positive organisms due to their fermentative activity for the manufacture of numerous food commodities and drinks, they play a significant role as particular spoiling organisms and the primary source of microbial changes in yoghurt. Yeast can thrive and grow at decreased temperatures and with high sugar concentrations (up to60%), which provides the capacity to multiplicate in yoghurt, particularly in fruit-based ones (Banjariet al., 2020).

El-Bakri and El-Zubeir (2009) evaluated 48 fruit yoghurt samples collected from retail outlets in Khartoum State, Sudan. The mean values of coliform count and yeast and moulds counts were 3.59±4.15 and 3.15±3.64 log CFU/g, respectively. The coliform count of samples varied significantly ($p\leq0.001$) between manufacturers and with a significantly higher ($p\leq0.05$) coliform count in samples collected from traditional manufacturers than those collected from modem manufacturers. After consuming contaminated yoghurt in Lahore in January 2011, one hospital staffer passed away, and two additional staff members had serious illnesses (Ians, 2011).

Sömer and Kılıç (2012)microbiologically evaluated thirty-three flavored yoghurt samples collected from markets in different provinces of Turkey (Afyon, Aydın, Burdur, Isparta, and Muğla). The mean values of coliforms and yeast & mould ranged from 6.01±0.53 to 6.63±0.52 Log CFU/g and 6.15±1.30 to 7.12±0.22 Log CFU/g, respectively. All the yoghurts were contaminated with fungi and coliforms at levels above the acceptable limits, indicating insufficient process hygiene and raising concerns about consumer safety.

El-Malt et al. (2013)examined 100 random flavored yogurt samples (small and large-scale) from various dairy shops, street vendors, and supermarkets located in Qena City, Egypt, collected between the years 2008 to 2010. *S. aureus* was detected in (72%) and (36%) with an average of 8.5×10^3 and 9.41×10^2 CFU/g for both small and large-scale yoghurt samples. Regarding yeast and moulds, they were found in (94%) and (40%) with an average count of 1.4×10^4 CFU/g for small-scale yoghurt samples and 3.9×10^2 CFU/g for large-scale yoghurt samples. The incidence of *E. coli* biotype I for examined small-scale yoghurt samples was (63.4%), while for the examined large-scale yoghurt samples was (16.7%).

The high levels of *E. coli* strain contamination in yogurt was found utilizing PCR and antibiotic susceptibility testing in Iran. The most *E. coli* isolated were the O157 serotype, the stx1,2, eaeA, and ehly genes, tetA, tetB, blaSHV, and citm antibiotic resistance genes, and ampicillin, penicillin, tetracycline, and streptomycin resistance genes. Cross-contamination and negligent hygienic measures during processing and packaging may be the cause of contamination (Dehkordi et al., 2014).

Szczawińskiet al.(2016)evaluate the *Listeria monocytogenes* state in manufactured yoghurt in the market and mentioned that storage time and temperature significantly affect the survival rate of *L. monocytogenes*in yoghurt. The *L. monocytogenes* level is closely associated with the yoghurt pH. The results illustrated that *L. monocytogenes* have unsuitable conditions forgrowth in yoghurt; however, these bacteria may survive in the output product for an extended time posing a hazard to yoghurt consumers. El-Leboudy et al. (2017) collected 20 flavored yogurt samples were collected from local shops in Alexandria City and microbiologically analyzed them. The mean value of *S. aureus* count, coliforms count, yeasts, and moulds count were 22±5, $4.10\times10^2\pm20$, $7.87\times10^4\pm 6.89\times10^4$, and $5.88\times10^4\pm 4.06\times10^4$ CFU/g, respectively, with 90%, 50%, 30%, and 45% compliance with the Egyptian Standards, 1999. *E. coli* was found in 25.0% of the analyzed samples.

Yang and Yoon (2022) recorded that the *L. monocytogenes* can survive in fermented milk stored in a fridge and EHEC has an efficient acid resistance that can survive in yoghurt with a low pH. Both pathogens had a positive association with the first contamination concentration and consumption. These results show that the foodborne disease risk from *L. monocytogenes* and EHEC due to yoghurt eating is very low. However, controlling the first contamination concentration of EHEC during yoghurt processing should be assured.

Yoghurt drink with fruits is considered a product that can improve human gastrointestinal tract function, helps digestion of lactose, reduces or prevents diarrhea, and strengthens the immune system. Yoghurt drinks or stirred yoghurt are generally preferred in Central Asia, Anatolia, Balkan as well Middle East countries and have total solid contents not exceeding 11.0%. The drinks have essentially undergone a homogenization to further reduce the viscosity with sweetener, flavoring, and coloring ingredients incorporated invariably (Saiful et al., 2021;Wijesekaraet al.,2022).

Abdallaet al. (2015)evaluated the quality of stirred yoghurt manufactured with Guddaim fruit in Khartoum North, Sudan. Addition of fruit puree; 5% v/v was done. Coliform bacteria count was log 3.69 CFU/g. Yeasts and moulds count was log 4.12 CFU/g. Aly and Galal (2016) analyzed the microbiological quality of 120 flavored drinking yogurt samples (30 strawberries, 30 mangos, 30 bananas, and 30 oranges) assembled from supermarkets in Cairo and Giza Governorates, Egypt. The mean values of aerobic spore formers were $1.3\times10^5 \pm 2.1\times10^4$, $3.2\times10^6 \pm 4.3\times10^5$, $6.9\times10^5 \pm 7.2\times10^4$, and $4.2\times10^6 \pm 6.6\times10^5$ CFU/g in different brands, respectively. The mean values of *Bacillus cereus* were 5.1×10^4, 1.1×10^4, 1.0×10^4, and 2.4×10^5 CFU/g, respectively, and the mean values of coliforms counts were 5.0×10^5, 4.7×10^6, 1.0×10^6, and 9.9×10^6 CFU/gin different brands, respectively. *Salmonella* spp. was not detected in all the examined samples.

According to El-Leboudyet al. (2017), twenty stirred yogurt samples were collected from local shops in Alexandria City and microbiologically analyzed. The mean value of *S. aureus* count was 20 ± 10 CFU/g and the value of coliforms count was <10 CFU/g, while *E. coli* was absent in all the examined samples. The yeasts mean count was $5.83\times10^3\pm 3.68\times10^3$ CFU/g, while the mean value of moulds count was $2.60\times10^3\pm1.12\times10^3$ CFU/g. According to the Egyptian Standards 1999, 80%, 100%, 70%, and 75% of the examined samples were in compliance with the standards of stirred yogurt for *S. aureus*, coliforms, yeast, and mould, respectively.

A total of twenty-four yoghurt samples were obtained from Ordu and Giresun cities, Turkey (20 made from cow's milk and four from buffalo's milk). The mean values of coliforms and yeast & mould in cow milk yoghurt were 1.22 and 5.54 log CFU/g, *E. coli* was found in one sample only. In the case of buffalo milk yoghurt, yeast & mould mean value was 6.08 Log CFU/g, while coliforms and *E. coli* were absent (Celik and Temiz, 2020). Adam et al. (2021) recorded the prevalence of *B. cereus*,Coagulase Positive Staphylococci, and coliforms were 6%, 18%, and 64% in the examined flavored yoghurt samples with mean values of $5.2×10^2$, $2.7×10^3$, and $8.5×10^2$, while in case of flavored drinking yoghurt the prevalence was 8%, 0%, and 32%. *Bacillus licheniformis* was found in 17.0% of samples. The *nhe*gene of *B. cereus* was the most found in all the investigated samples. *E. coli, Salmonella* spp., and *P. aeruginosa* were absent in all samples.

Tolu and Altun (2022) microbiologically evaluated 15 homemade and 15 commercial yoghurt samples obtained from Van City, Turkey, and reported that the mean count of yeast and mould in homemade yoghurt samples (6.02±0.71 log CFU/g) was lower than the mean count of commercial yoghurt samples (3.63±2.09 log CFU/g). Production practices, storage circumstances, and contaminations were the main causes of the variations in yeast and mould populations.

Two hundred samples of plain yoghurt were randomly purchased from various marketplaces in the governorate of Qalyubia, Egypt in a study carried out by Fetouh et al. (2022), *E. coli*, *B. cereus*, and *E. faecalis* were detected in 4%, 4%, and 5.5% of the examined samples, respectively. The mould and yeast isolates were found in 18.5% and 40% of the examined samples, respectively. Madani et al. (2022) investigated the prevalence of *E. coli* in yoghurt and yoghurt drink samples (10 samples for each) gathered from Isfahan, Iran. The incidence of *E. coli* isolated from yoghurt was 30% with virulence factors of 20% as (*st*), while in the case of yoghurt drink, *E.coli* was detected in 30% of the examined samples with virulence factors of 30% as (*bfpA+eaeA*,*ial*, and *stx2*).

DISCUSSION

Food safety challenges in Middle East countries include unsafe water and poor environmental hygiene, weak foodborne disease surveillance, the inability of small and medium-scale producers to provide safe food, outdated food regulations, and inadequate law enforcement, as well as insufficient cooperation among stakeholders (WHO, 2015).

Owing to their remarkable composition and properties, cheese provides an ideal growing medium for not only spoilage but also pathogenic bacteria, especially psychrotrophic, spore-forming bacteria, *S.aureus*, *Salmonella* spp., *E.coli O157:H7* during cheese processing which causes economic consequences and many foods borne outbreaks to consumers (Cancino-Padilla et al., 2017). The contamination of cheese with microbial pathogens could initiate from several sources during cheese production, for example, starter culture, cheese vat, floor, brine, packaging material, curd cutting knife, cheesecloth, production room air, and refrigerating room, as well as post-pasteurization contamination. This may be a result of cross-contamination of the finished product with the raw product, inadequate sanitation procedures in the plant environment, or inadequately sanitized equipment. Contamination after pasteurization, processing and handling procedure, utensils, plus improper temperature control during shipment and storage might result in high levels of pathogenic microorganisms in cheese (Ainiet al.,2019).

White cheeses have been traditionally made from raw milk and their flavor is strong and opulent. Small dairy farms continue to utilize raw milk, whereas bigger plants use thermized milk, which is milk, heated at 65°C for 15-18 seconds. Even though thermization kills some harmful germs, others may survive and contaminate the finished product, such as (*E. coli* O157). Several factors influence the survival of these organisms, including initial contamination level, heat treatment, acid and salt tolerance, microflora antagonism, cheese composition, and manufacturing circumstances; thus, protection of public health necessitate pasteurization to produce a high-quality safe product (Bintsis and Papademas, 2002).

In comparison to hard cheese, soft cheese contains more moisture, and because of microbial deterioration, soft cheese has a shorter shelf life. Due to the metabolic activity of contaminating bacteria and fungi, the majority of soft, unripened cheeses are microbiologically unstable (Tannous, 1991). In general, the presence of Enterobacteriaceae in dairy products suggests that the product was directly or indirectly contaminated with feces during processing; raising the likelihood that it included harmful bacteria and viruses.

Salmonella and *S. aureus* contamination in dairy products suggests improper handling or sanitation, which poses a risk to consumers. Government officials should stress and monitor these newly necessary cleaning and safety standards for cheese producers. The lactic acid bacteria and the inherent characteristics of the cheese do not promote yeast growth in soft cheese, which results in the fact that the microbial flora of this cheese is composed primarily of bacteria rather than fungi (Haddad and Yamani, 2017).

The majority of microbiological problems in white-brined cheese are caused by fungal development, particularly on the surfaces of cheese blocks (Fröhlich-Wyderet al., 2019). Fungi are typical pollutants of milk products because they offer suitable conditions for fungal growth. Fungi are acid-tolerant, xerotolerant, or psychrotolerant, and to some extent can tolerate chemical preservatives, which are sometimes legally added to increase product shelf-life. From dairy farms to dairy production plants to customers' homes, fungus contamination of dairy products can happen at several stages. Because fungus spores are easily carried into the air, mould deterioration is frequently caused by airborne fungi. Additionally, a consumer's home's interior air can be a serious cause of mould deterioration. Furthermore, mould spoilage can come from packing materials. Contrarily, yeast that causes spoilage typically comes through contaminated brine, contact surfaces, utensils, or ingredients. However, it can also be found in the air. The brine used for cheese salting is one of the most significant sources of yeast (Suranská et al., 2016).

Even though fermented dairy products have many health advantages, contamination could result in significant financial and health risks, necessitating the use of effective early detection techniques in the fermented dairy sectors throughout the entire production process until the goods reach consumers. The potential for cross-contamination during processing or contamination at the source is two factors that can result in these dangers. In terms of both safety and financial requirements, the advantages of swiftly identifying and diagnosing spoilage/pathogenic bacteria and toxins earlier in the production of fermented dairy products would be significant (El-Sayed et al., 2022). Therefore, it is imperative to gain knowledge of microbiological contaminants and toxin discrimination.

Although bacteria are capable of causing food to deteriorate, yeasts and moulds are frequently responsible for the spoilage of yoghurt. They are a significant contributor to yoghurt deterioration, and yoghurt's acidic pH encourages their proliferation. The presence of yeasts and moulds in flavored fermented yoghurt is undesirable even in small amounts due to the resulting objectionable changes that lower the product's quality. They are responsible for off-flavors, loss of texture quality due to gas production, and package swelling and shrinkage. More so, moulds and yeasts growing in yoghurt utilize some of the acids and produce a corresponding decrease in acidity, making the food environment more susceptible to proteolysis and putrefaction by bacteria (Rodrigues et al., 2010).

The fermentation method was used to produce high-quality products prior to the addition of additives in the yoghurt-based product. However, during drinking yoghurt manufacturing, bad sanitation and preparation could lead to unwanted contamination through bacteria or fungi. Yeast and mould can easily grow on dairy food with high sugar or salt content and cause food spoilage. The acidic resistant properties of yeast and mould make them able to survive in extreme conditions, thus causing spoilage and economic losses for some dairy products (Perricone et al., 2017). It is difficult for pathogens to survive in drinking yoghurt because it has high acidity values (between pH 3.8-4.2). However, it can be damaged by acidic organisms such as fungi. For example, the lactose fermentation yeasts (*Kluyveromycesfragilis*) and yeast in fruits (*Saccharomyces cerevisiae*) are important for yoghurt development. But yeast such as *Geotrichum* and moulds that grow on surfaces such as *Mucor*, *Rhizopus*, *Aspergillus*, *Penicillium*, and *Alternaria* can cause dairy damage. To assure the safety of yoghurt beverages, rapid detection methods, and sensitive, cost-effective, and easy-to-use tools are required (Saifulet al., 2021).

Since consumers purchase drinkable yoghurt for its flavor and components, a range of flavors are utilized in its production, including plain (natural) and a broad array of flavors such as banana, mango, strawberry, apricot, and apple. These flavors are usually introduced to drinkable yoghurt after the pasteurization and fermentation processes have been finished. As a result, the microbial threat may be critical to the drinkable yoghurt market (Rad et al., 2019; Allam et al., 2023). The incorporated fruit purees, which are frequently contaminated due to poor handling practices, are the main cause of contamination. Furthermore, the existence of these organisms indicates a deficit in heat processing or contamination after pasteurization (Aly and Galal,2016).One of the best ways to avoid *B. cereus* poisoning is to utilize raw materials with fewer spores. Spores can spread to other milk products through unheated milk or dairy equipment. In contrast to the *cytK* toxin, which causes bloody diarrhea, the *nhe* toxin possesses deadly poisoning, cellular hemolytic, necrotic effects, hepatic damage, and sugar problems induced by cytotoxic genes (Caro-Astorga et al., 2020; Jessberger et al., 2020).

Finally, aerobic spore formers, *B. cereus*, total staphylococci, coagulase-positive staphylococci, coliforms, total yeast, and mould have existed in variable counts in dairy products and cheese substitute samples in the Middle East. Therefore, increase awareness of dairy products manufacturers and consumers. Food safety education programs should be incorporated into school curricula to improve food safety cognition among students and promote life-long safe food handling behavior. As part of the product's quality control inspection by the government, white cheese should be tested for phosphatase.

CONCLUSIONS

This review notified that some of the cheeses and fermented milk sold in Middle Eastern nations may not have appropriate microbiological quality. This implies that in order to prevent contamination with germs, strong hygienic measures must be used during the production, processing, and distribution of these products. Governmental regulatory agencies should conduct inspections of the dairy products business to keep an eye on the poor hygienic conditions and to impose penalties if needed. It is advised to apply hurdle technology and take advantage of the beneficial probiotic bacteria found in fermented milk. To meet the standards;good manufacturing practices (GMPs) and food safety management systems (ISO 22000:2018) adoption in dairy processing plants should be prioritized.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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