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Quality and safety of cheese shipped to the United Arab Emirates

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Abstract

During an examination of 3299 cheeses imported into the United Arab Emirates (UAE) from 2017 to 2021 for compliance with regulations regarding moisture and fat content, microbial quality, acidity, the presence of quinoline (a non-permitted colorant), sorbic acid, and the presence of rust discoloration, it was found that 91% of cheeses were compliant with UAE legislation. However, 9% were in violation of one or more of the mandated quality parameters, suggesting that adulteration had occurred. Within product categories the greatest level of non-conformity at 13% was noted for processed cheese, primarily due to violations caused by high moisture and low-fat content. This is important because moisture levels in processed cheese can influence its texture and shelf life. The microbial assessment of cheese showed that 85.7% of semi-hard and 77.5% of soft cheeses had non-compliant levels of *E. coli*. It was notable that 21.8% of non-compliant products originated from Turkey. Cheeses from Germany had the lowest level of non-conformity at 0.6%. This study illustrates the need for border scrutiny to include physicochemical examinations of cheese samples. The current initiative aims to promote the need for equity in global trade and to prevent the marketing of adulterated food items.

Keywords Imported cheese, Fraud, Adulteration, Non-conformity, Moisture content, Fat content

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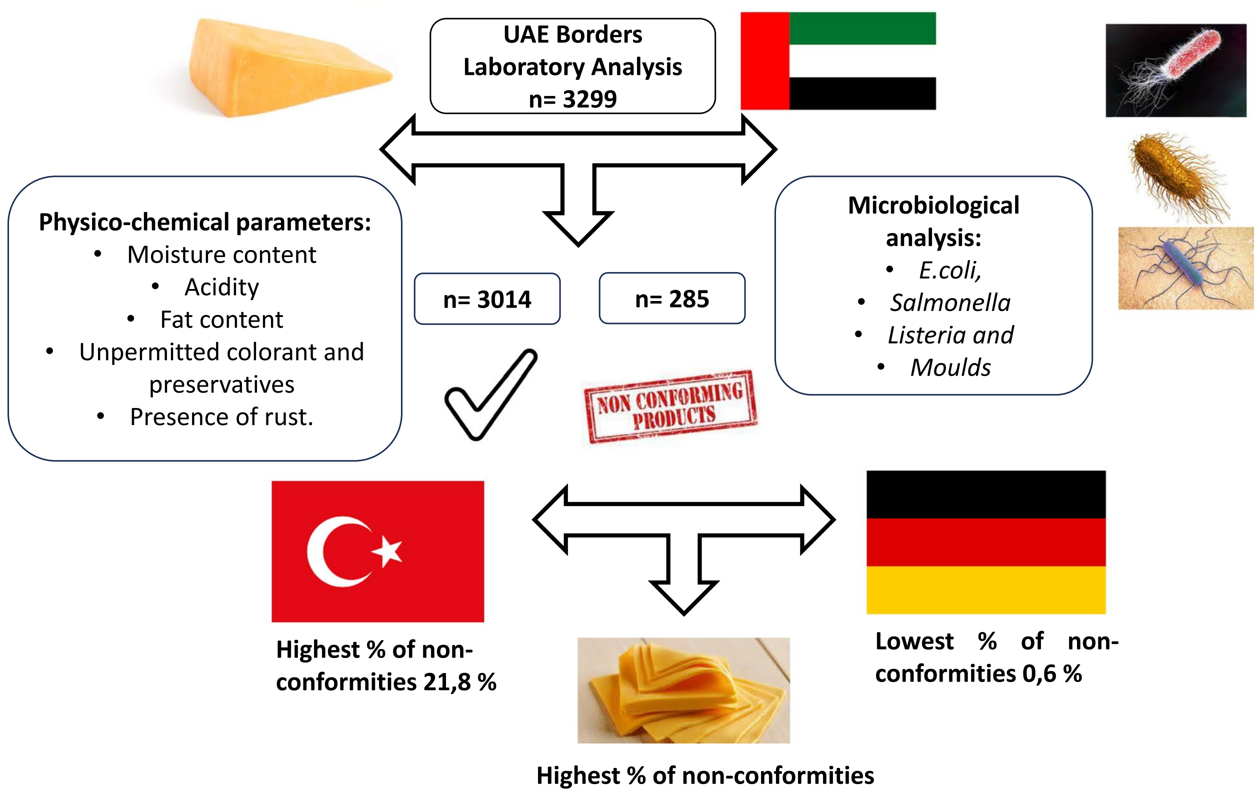
Graphical Abstract



Introduction

Global significance of cheese

Dairy products serve a vital role in human diets around the globe, due to their significant nutritional benefit. It was noted by the United Nations that about 6 billion people use dairy and milk products, with developing countries showing the greatest consumption (FAO 2013). Cheese is one of the most common foods consumed, to the extent that world cheese production in 2022 was about 22.17 million metric tons (Statista 2023).

Due to the increasing complexity and globalization of the food supply chain, new issues constantly arise in terms of the quality and safety of food products imported to the United Arab Emirates (UAE). In the cheese sector, maintaining quality and safety faces a variety of hurdles. Microbial contamination represents a constant risk, potentially causing spoilage or health concerns. The requirements of stringent regulations add complexity, and the intricacies of the supply chain introduce vulnerabilities that can influence the final product quality. Tackling these challenges involves stringent quality control, technological innovation, adherence to safety protocols, and continuous monitoring across the production and distribution chain (Hernández-Castellano et al. 2019).

Challenges in the food supply chain

In particular, cheeses from all over the world are imported into the UAE and many face regulatory challenges. Issues related to product quality (cheese composition including fat content, presence of preservatives) and microbial and safety parameters (presence of spoilage and pathogenic microorganisms) are recognized regulatory concerns (Code 2020). To deal with these challenges, food producers, importers, and regulators have become reliant upon food quality and safety standards/specifications, although this practice has not been universally adopted. It is significant that during 2000–2020, the Rapid Alert System for Food and Feed (RASFF) notifications for milk and milk products showed that cheese was the most frequently notified product at 84.4% (Postolache et al. 2020).

Throughout the cheese manufacturing process, from farm to processor, many health hazards can occur either intentionally or accidentally (Kojok et al. 2022).

According to the RASFF fraud and safety data on cheese over the past 5 years, notifications were mainly related to safety alerts, where foodborne pathogens represented 68.4% of the food safety hazards. Foreign material, fraud, sensory defects and antibiotic residues were reported as well (Zouhairi et al. 2010). Dairy products are known to be potential hosts for a variety of organisms including coliforms, *Salmonella*, *Escherichia coli*, *Listeria monocytogenes* and *Staphylococcus aureus*, since they can be associated with or responsible for transmission of infectious diseases (Oliver et al. 2005). It is not surprising that dairy products have been the vehicles for a number of foodborne illness outbreaks caused by *E. coli* (Oliver et al. 2005; Silva et al. 2023a, b), *Staphylococcal* enterotoxin (Yamashita et al. 2003), *Salmonella* (Bedassa et al. 2023; Olsen et al. 2004) and *L. monocytogenes* (Carrique-Mas et al. 2003; Silva et al. 2023a, b).

Regulatory concerns

Cheeses are distinguished not only by their appearance and flavor, but also by their moisture content, and the latter enables their classification as soft, semi-soft, semi-hard, hard or very hard (Farkye 2004). Those that are soft are un-ripened cheeses ready for consumption directly after processing. They are highly susceptible to microbial contamination due to high moisture content (50–65%) (Humeid et al. 1990). Soft, semi-hard and hard cheeses are at significant risk from foodborne pathogens, particularly *L. monocytogenes.* These products are matured for 30—90 days and represent the most popular group of ripened cheeses. After maturation, their moisture content is in the range of 39– 69% (Morin-Sardin et al. 2016). Processed cheese is created following the mixing and heating of various types of cheese with other ingredients (Kapoor & Metzger 2008). Processed cheese usually has a pH of 5.1, which is lower than the cheese ingredients, and has a water activity of 0.93 with better keeping quality due to the heat treatment used in its manufacture (Angelidis et al. 2013).

To identify fraudulent practices, several cheese quality parameters such as acidity, moisture, fat, colorant and sorbic acid content can be measured. Determination of cheese moisture and acidity is key to establishing product identity (Lee et al. 2004). Fat content has economic implications and is a characteristic also used to classify cheeses. Since regulations specify what, where, when and the amounts of all food additives that may be present in cheeses, the presence of these materials must be determined (Koca et al. 2022).

Specific risks associated with cheeses

This study aims to explore the composition of imported dairy products to enable assessment of their safety, shelf life, and authenticity. Work is specifically focused on cheeses imported into the UAE, an area lacking previous scrutiny. By meticulously assessing the quality and safety status of cheeses imported to the UAE through Dubai ports from 2017 to 2021, the study was designed to identify and address specific issues leading to rejection or failure to meet local standards. The quality parameters monitored included moisture content, acidity, fat, sorbic acid, addition of non-permitted colorant, and the presence of metallic rust. The microbial parameters involved monitoring for *E. coli*, *Salmonella*, *L. monocytogenes* and molds. Additionally, the investigation attempted to discover patterns in reasons for rejection across different countries, providing insight to improve import quality and foster collaboration between exporting and importing nations to achieve better dairy products.

Materials and methods

Sampling

From 2017 to 2021, 3299 cheeses originating from 47 countries transported in carts, refrigerated trucks or containers were obtained from warehouses in the Dubai ports. Samples were grouped according to moisture and included 1094 samples of soft cheese, 121 semi-soft cheeses, 987 semi-hard cheeses, 74 hard cheeses, and 1023 processed cheeses. Each of these cheese classes included a number of types as shown in Table 1. Authorized food control inspectors employed by the municipality of Dubai supervised the collection of samples. These were placed into separate sterile plastic bags, put on ice in an insulated container and sent to the analytical laboratories of the municipality of Dubai. The sample techniques and methods followed were those recommended by EU Directive 2002/63/EC (EU 2002).

Determination of quality parameters of cheese

Moisture, fat content, pH, and titratable acidity

Analyses for moisture (AOAC 925.10), fat content (AOAC 2003.05), pH (AOAC 981.12), and titratable acidity (AOAC 942.15), were conducted using AOAC (2007) procedures.

Colorant detection in cheese

As is normal regulatory practice, cheese samples were tested for color only if artificial colors were declared. The presence of synthetic colors was identified by a paper chromatographic technique.

Determination of sorbic acid in cheese

AOAC method 971.15 (AOAC 1971) was used to determine sorbic acid in cheese. A cheese sample weighing 10 g was chopped and added to 100 ml of deionized water having a conductivity less than 2 µS (micro-Siemens).

Table 1 Classification of cheeses

Classes of Cheeses	Type of cheeses
Soft cheeses	White cheese, feta cheese, cottage, cow's milk cheese, paneer, brie, mascarpone, pasteurized, istanbuli, low salt cheese, blue, soft cheese, areesh cheese, quark cheese, cheese topping, neufchatel cheese, reblochon
Semi - soft Cheese	Full fat cheese, cheese sticks, gorgonzola, havarti, cheese analogue, mashmoula, saint-nectaire, taleggio
Semi - hard Cheese	Mozarella, halloumi, goat, low fat cheese, akkawi, burrata, string cheese, shredded cheese, tulum, baramily, sheep and goat, fat-free cheese
Hard cheese	Cheddar, sheep, cheese powder, yellow cheese
Processed cheese	Processed cheese, cream, cheese spread, camembert, ricotta

The mixture was then evaporated by steam distillation. The collected distillate was passed through a 0.45 µm Millex-HA hydrophilic filter (Merck & Co, NJ, USA) and then into a UPLC/HPLC system (Ultimate 3000 Series, Thermo Fisher Scientific Inc., MA, USA) equipped with a diode array detector operating at 230 nm. A calibration curve that plotted peak area against sorbic acid concentration was constructed and results were expressed as mg sorbic acid/kg of cheese.

Rust in cheese

Cheese samples were observed visually for any rust spot discoloration from the container if metal was used.

Determination of microbial and safety parameters of cheese

Cheese samples were examined for *Escherichia coli*, *Salmonella*, *Listeria monocytogenes* and molds using rapid techniques as indicated below.

Rapid *Escherichia coli* enumeration:

E. coli enumeration was conducted using selective *E. coli* 3 M Petrifilm (3 M Science, MN, USA). Cheese weighing 25 g was aseptically homogenized with 225 mL of 0.1% peptone water. A 1.0 mL sample of appropriate dilutions was plated on each 3 M Petrifilm *E. coli* count plate. The plates were incubated at 42 ± 1 °C for 18–24 h. Following incubation, blue colonies on the Petrifilm were used to estimate the total number of *E. coli* present.

Rapid *Salmonella* spp. detection

Salmonella spp. detection was done using 3M Molecular Detection System (MDS, 3M Science) Assay (AOAC Official Method 2016.01). Cheese samples weighing 25 g were aseptically weighed, mixed with 225 mL buffered peptone water and incubated at 37°C for 18–24 h. A 3M MDA Isothermal Chain Reaction (3M Science) was used for screening. A volume of 20 µL of each pre-enriched sample was added to a lysis tube, and placed in a heating block for 15 min at 100 ± 1°C, as suggested by the manufacturer. Then, these tubes were chilled for 10 min. Tubes were then held at room temperature for 5 min, and then 20 µL of each lysate was transferred to a glass tube and mixed gently. After that, the tubes were placed in a 3M Molecular Detection tray and loaded into the 3M MDS unit. Presumptive positives were reported first, while negative results were obtained following a 75 min default interval.

Rapid enumeration of *Listeria monocytogenes*

Enumeration of *L. monocytogenes* was done using a 3M Molecular Detection System (MDS, 3M Science) Assay (AOAC Official Method 2016.08). Each cheese sample weighing 25 g was mixed with 225 mL half Fraser selective broth enrichment and incubated for 24 h at 37°C. A 3M MDA Isothermal Chain Reaction system (3M Science) was used for screening. Then, 20 ml of sample lysate was taken and placed into a reagent tube, a 3M Molecular Detection Matrix Control tube, and mixed thoroughly. DNA was extracted from 20 uL of enriched half Fraser broth. Following transfer and mixing, the samples were placed into the 3M Molecular Detection Tray and loaded into the 3M Molecular Detection unit. Presumptive positive results were obtained within 75 min, whereas negative results were available after the run was completed. The confirmation of presumptive positive results was made using ISO method 11290–1:2017, Horizontal method for the detection *Listeria monocytogenes* -Part 1 (ISO 2017).

Molds and physical contaminant detection

Visual monitoring was used to detect mold and the presence of hair or other foreign material in cheese samples.

Statistical analysis

To compare proportions of conforming and non-conforming cheese samples during the 2017 to 2021 study, a Chi-square test was used (IBM SPSS Statistics, version 26). Statistical difference was denoted at $p < 0.05$.

Results and discussion

Compliance of imported cheese with standards

Table 2 reports imported cheese conformity with the current UAE cheese standard (UAE.S.147 2017), as presented in Table 3. The data are organized to identify the cheese types at higher risk of adulteration. The analysis of 3299 samples showed 9% of cheese samples were non-compliant with UAE legislation.

During further analysis it was found that the proportion of non-compliance, based on the cheese class, ranged from 1 to 13%. Among the various classes of cheeses, the lowest level of non-compliance was found for semi-soft cheese (1%) and the highest for processed cheese (13%). This suggested that processed cheese was more susceptible to quality fraud than other types of cheeses.

Table 4 presents annual cheese compliance during the 5-year survey. During the years examined in the study, only 2017 was shown to have a significantly different and greater number of non-conforming samples than the other years. Paired comparisons showed there was no significant difference between 2018 and 2021 and 2019 and 2020.

Table 2 Summary of imported cheese compliance with UAE standards from 2017 to 2021

Type of cheese	No. of samples	No. of compliant samples (%)	No. of non-compliant samples (%)
Soft cheeses	1094	1027 (94)	67 (6)
Semi-soft Cheese	121	120 (99)	1 (1)
Semi-hard Cheese	987	903 (91)	84 (9)
Hard cheese	74	70 (95)	4 (5)
Processed cheese	1023	894 (87)	129 (13)
Total	3299	3014 (91)	285 (9)

Compliance of imported cheese with recognized standards

In this study, the 3299 cheese samples were subjected to quality and safety compliance assessment with the Emirates Microbiological criteria for foods issued by the Authority for Standards & Metrology (ESMA) (UAE.S 1016 2017). The resulting means and ranges of the 285 non-conforming cheese samples, according to the type of cheese, are presented in Table 5.

Physicochemical assessment of cheese

The mean moisture content in non-compliant cheese types was 33.7%. Among these, processed cheese had the highest percentage (65%), with 84/129 non-conforming samples having an average moisture content of 57.9%. The moisture variation in processed cheese (46.5–85.3%) likely resulted from the variability of raw materials and process conditions (Bradley 2010). Controlling moisture content is critical in processed cheese, since it can affect texture properties and shelf life of the products (Pereira et al. 2001). Elevated moisture can create favorable conditions for the proliferation of spoilage bacteria, yeasts, and molds, leading to accelerated spoilage and potential health risks. Conversely, insufficient moisture can hinder the growth of desirable ripening bacteria and molds, essential for flavor development in certain types of cheese. Maintaining the appropriate moisture content helps achieve microbial stability.

Table 5 shows that the highest mean value of moisture (69.3%) was found for semi-hard cheese ($n=84$). This type of cheese was also found to have the greatest extent of *E. coli* non-conformity (85.7%). This is in agreement

Table 3 UAE cheese standards (UAE.S.147 2017)

	Soft and semi-soft cheese	Semi-hard cheese	Hard cheese	Processed cheese
Moisture	60–62%	60–62%	Max 48%	Max 45%
Acidity	Min 1.2%			
Fat%	min 40%			Min 45%
Quinoline colorant	Absent			
Sorbic acid	Limit max 1000 mg/kg			
Rust	Absent			
E. coli	10–100 cfu/g[a]	10–100 cfu/g[b]		Detected /g or Not Detected/g[c]
Salmonella spp.	Absent in 25 g			
L. monocytogenes	Absent in 25 g			
Molds	Absent in 25 g			

[a] Allowing 2/5 units to exceed 10 cfu/g but not equal 100cfu/g and no units (0/5) is allowed to equal or be greater than 100 cfu/g)

[b] Allowing 1/5 units to exceed 10 cfu/g but not equal 100cfu/g and no units (0/5) is allowed to equal or be greater than 100 cfu/g)

[c] No units (0/5) is allowed to be Detected/g

Table 4 Imported cheese compliance from 2017 to 2021 using Chi-square analysis

Type of Cheese	Conform ($n = 3014$)	Not-conform ($n = 285$)	p-value
2017 ($n = 611$)	494 (80.9%)^{aA}	117 (19.1%)^{bA}	< 0.001
2018 ($n = 660$)	607 (92.0%)^{aB}	53 (8.0%)^{bB}	
2019 ($n = 765$)	730 (95.4%)^{aC}	35 (4.6%)^{bC}	
2020 ($n = 625$)	597 (95.5%)^{aB}	28 (4.5%)^{bC}	
2021 ($n = 638$)	586 (91.8%)^{aB}	52 (8.2%)^{bB}	
Total ($n = 3299$)	**3014**	**285**	

^{a,b}Different letters indicate significant differences in the proportions of conform and not conform samples across the individual years ($p < 0.001$)

^{A,B,C}Different letters indicate significant differences in the proportions of conform and not conform samples across the different years ($p < 0.001$)

with the study by Varga (2007), where it was found that high moisture cheeses in Hungary were prone to spoilage by various microorganisms that contaminated the products post-pasteurization.

Acidity levels were found to be non-compliant only in one sample of soft cheese that had a value of 0.77%, which was substantially below the minimum permitted level of 1.2%. It should be noted that maintaining a minimum acidity of 1.2% in cheese ensures proper preservation, enhances flavor development, supports microbial stability, and contributes to food safety (Jalilzadeh et al. 2015). Fat content was not conformant in 31 of 285, or 10.8% of samples. The highest non-conformity was shown in processed cheese where 22 of 129 samples, and this was equivalent to a percent non-compliance of 17%. The mean fat content in these samples was 35% but should have been above the required minimum of 45%. Maintaining a minimum fat content of 40% in cheese is crucial as it not only contributes to cheese texture, flavor, and mouthfeel, but also facilitates the proper distribution of flavor compounds, aids in moisture retention, and ensures structural integrity during the aging process (Verdier-Metz et al. 2001).

Non-permitted colorant, which includes quinoline, was found in one sample of soft cheese. Quinoline yellow, known as E104 or D&C Yellow#10, is banned in the UAE and the USA because it increases the hyperactivity level in children when used in a mixture with other preservatives (FDA, 2021). Sorbic acid exceeding the UAE acceptable limit of 1000 mg/kg was found in one sample of soft cheese, where 1124 mg/kg was present. The European regulatory limit of sorbic acid is < 1000 mg/kg (EFSA, 2015). Historically, sorbic acid was used at first by applying it to the wrapper to protect cheeses (Melnick & Luckmann, 1954). Subsequently it was found that it permeated the cheese, yielding reduced fungistatic activity at the cheese surface (Wood et al., 2020). It is currently used as a surface preservative for cheese because of its anti-bacterial and fungistatic activity. Rust was shown to be present in one sample of semi-hard cheese packed in a metal container. Rust should be absent from cheese (or any food) because its presence suggests deterioration of food contact surfaces, considered a manufacturing flaw and health hazard. Rust typically forms when metal comes into contact with moisture and oxygen, creating an opportunity for metal oxide contamination and creating surface irregularities that can promote biofilm formation. Undesirable changes in safety, quality, and taste can result. Thus, ensuring the absence of rust in cheese is crucial for maintaining food safety and quality standards.

Microbiological safety assessment of cheese

The production of cheese should be in accordance with legal regulations as shown in Table 3. The non-conformity of samples due to high microbiological load is shown in Table 5. Of the 285 non-conforming samples, 131 (46%) were shown to be non-compliant because *E. coli* numbers exceeded the acceptable limit. Three samples were non-conforming due to the presence of molds and two samples were contaminated with *L. monocytogenes*. It was notable that none of the cheese samples was contaminated with *Salmonella* spp. A similar study conducted by Varga (2007) assessing the microbiological quality of cheese revealed that a number of types of cheeses exhibited a non-compliance rate of 30%. *E. coli* and coliforms are considered indicators of sanitary quality of cheeses (Metz et al. 2020). The high *E. coli* load in tested cheeses indicates either inadequate pasteurization of milk or post-pasteurization contamination during the cheese manufacturing process, or both (Kamana et al. 2014). It should be emphasized that raw milk may be contaminated with foodborne pathogens such as *Salmonella, L. monocytogenes*, pathogenic *E. coli* strains (i.e., *E. coli* O157:H7), and *S. aureus* from the farm environment (Kousta et al., 2010). Typically, pasteurization effectively eliminates harmful bacteria. However, if milk undergoes inadequate or poorly controlled pasteurization, coupled with improper storage, proliferation of bacteria can result, reducing the shelf life of milk and dairy products like cheese, and potentially causing foodborne illnesses. Using high quality raw milk and implementing stringent hygienic measures are essential for enhancing process control in the production of dairy products (Bricker et al. 2005). The *E. coli* content according to the type of cheese is shown in Table 5 where the highest number of non-conformities was for semi-hard cheese with 72 of 84 or 85.7% being non-compliant, and having a mean of 20,470 cfu/g (an acceptable level is 10–100 cfu/g). This was followed by soft cheese with 52 of 67 or 77.5% of samples being non-compliant, and they had a mean value of 2,183 cfu/g. A

Table 5 Identification of non-compliant quality parameters among the 285 imported, non-compliant cheese samples

Type of Non-Compliant Cheese		Moisture	Acidity	Fat %	Unpermitted colorant (Quinoline)	Sorbic acid	Rust	*E. coli*	Molds	*L. monocytogenes* (Limit 0/25 g)	Violations involving multiple Non-compliant Parameters
Soft cheese ($n = 67$)	No. (%)	8 (12)	1 (1.5%)	2 (3%)	1 (1.5%)	1 (1.5%)		52 (77.5%)	1 (1.5%)		1 (1.5%)
	Mean	64.75	0.77	38.25		1,124		2,183			
	Range	62.7–68.2	0.77	38.1–38.4				40–12,000			
Semi-soft cheese ($n = 1$)	No. (%)								1 (100%)		
	Mean (%)										
	Range										
Semi-hard cheese ($n = 84$)	No. (%)	2 (2.4%)	0 (0%)	7 (8.3%)	0 (0%)		1 (1.2%)	72 (85.7%)	1 (2.4%)		1 (1.2%)
	Mean	69.3		33.9				20,470			
	Range	67–71.6		26.2–42				20–545,000			
Hard Cheese ($n = 4$)	No. (%)	2 (50%)						2 (50%)			
	Mean	55.7						950			
	Range	55.3–56.1						100–1,800			
Processed cheese ($n = 129$)	No. (%)	84 (65%)		22 (17%)				5 (4%)		2 (1.6%)	16 (12.5%)
	Mean	57.9		35				230			
	Range	46.5–85.3		14.4–59				210–280			
Total number of non-compliant samples (285)	**No. (%)**	**96 (33.7%)**	**1 (0.4%)**	**31 (10.9%)**	**1 (0.4%)**	**1 (0.4%)**	**1 (0.4%)**	**131 (46%)**	**3 (1.1%)**	**2 (0.7%)**	**18 (6.3%)**

similar study conducted by Aygun et al., (2005) assessed the microbial load of 50 semi-hard cheese samples and showed that 82% of samples were non-compliant. A study conducted by Varga (2007) found that about 50% of the soft cheese samples ($n = 28$) examined exceeded regulatory standards. A similar study conducted by Araújo et al., (2002) examined 45 samples of soft cheese collected from the Brazilian market for fecal coliforms and found that 95% of the samples were non-compliant with standards, making them unsuitable for human consumption.

A low number of microbial non-conformities was shown for processed cheese, with only 5 of 129 samples or 4% being non-compliant. This is similar to results from a study conducted by Nazem et al., (2010). During a microbiological assessment of 100 samples of processed cheese taken from the Alexandria Market, all samples conformed with the Egyptian cheese standard and coliforms were not detected in any variety of the processed cheeses examined. The results of this work are also consistent with those found in a study by Kung et al. (2005), where it was shown that *E. coli* was absent from 39 processed cheese products collected from food markets in Taiwan. In another study conducted by Varga (2007) excellent compliance in terms of microbial quality was found with 10 samples of processed cheese purchased from food stores located in the western part of Hungary. The low microbial load found in processed cheese likely resulted from the inactivation of vegetative bacteria during the heat treatment normally used during processed cheese manufacture (Buňková & Buňka, 2017).

In general, it is expected that a high number of undesirable bacteria in some cheeses is likely due to poor hygienic practices, inadequate storage conditions, inadequate refrigeration, or unacceptable control of heat treatments. Microbial contamination of cheese could also be influenced by bacterial growth in milk before the production of cheese, and in the case of brine-ripened products, placing cheeses in improperly prepared/stored brine solutions (Haddad & Yamani, 2017).

Combination of non-compliant parameters

Of 285 non-conforming cheeses found in this study, 18 or 6.3% of samples were shown to be non-compliant with respect to more than one regulatory criterion. Samples deficient in both moisture and fat were most frequent and represented 15/18 or 83.3% of non-compliant samples. Two combined violations were noted for *E. coli* and molds, and for *L. monocytogenes* and *E. coli,* where numbers present were above those permitted. Finally, a combined violation was shown for a sample having detectable hair plus numbers of *E. coli* above the permitted limit.

Classification of cheese non-conformities according to the country of origin

The distribution of the 285 non-conforming cheese samples by country of origin and cheese type is shown in Fig. 1. For non-conforming samples of soft cheese ($n = 67$) and semi-hard cheese ($n = 84$), Turkey was shown to be the main country of origin with 43% and 58% of products non-compliant, respectively. Egypt had the second highest level of non-conformities for soft cheeses, at 13.5%. Italy had the second most frequent number of semi-hard cheese non-conformities

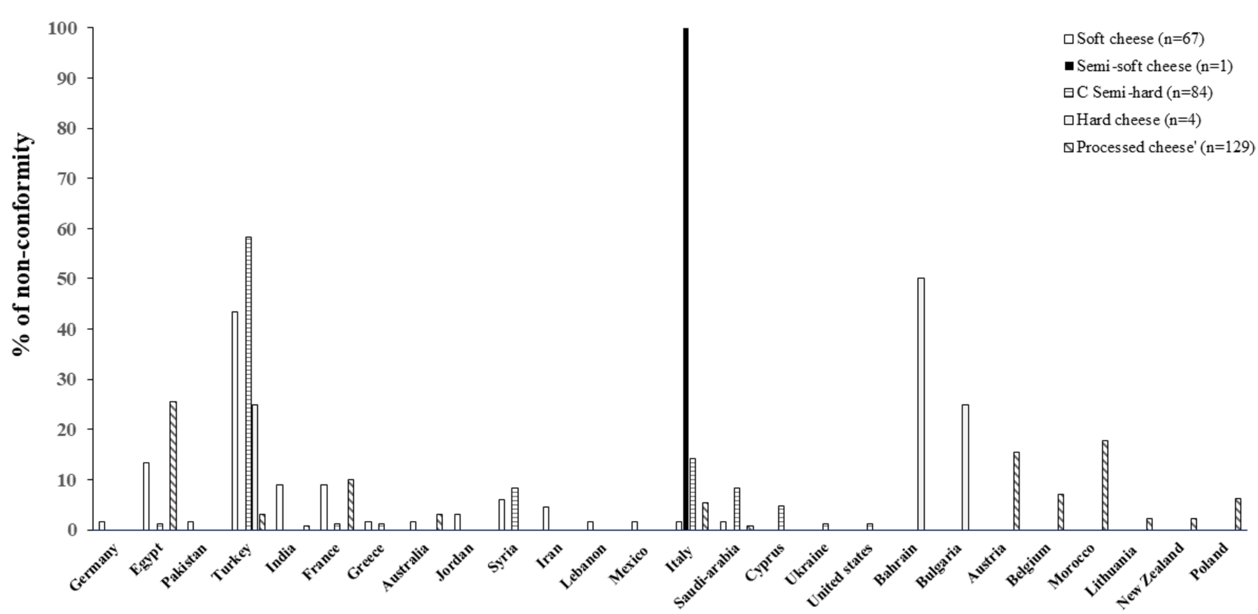


Fig. 1 Percentage of non-conforming samples for each type of cheese according to the country of origin

Table 6 Number of non-conforming cheese samples (%) according to the country of origin and type of cheese

Country (N_0 of Imported sample) *n* = 3299	N0. Of Imported Samples (No. of rejected Samples, %)				
	Soft Cheese	**Semi-soft cheese**	**Semi-Hard cheese**	**Hard cheese**	**Processed cheese**
Egypt (473)[a]	230[b] (9[c], 4[d])	8 (0, 0)	30 (1, 3.3)	16 (0, 0)	189 (33, 17)
France (383)	136 (6, 4.4)	6 (0, 0)	86 (1, 1.1)	10 (0, 0)	145 (13, 9)
Turkey (380)	152 (29, 19)	28 (0, 0)	158 (49, 31)	8 (1, 12.5)	34 (4, 11.7)
Italy (345)	74 (1, 1.35)	15 (1, 6.67)	201 (12, 6)	5 (0, 0)	50 (7, 14)
Germany (159)	23 (1, 4.3)	6 (0, 0)	54 (0, 4)	1 (0, 0)	75 (0, 4)
India (137)	120 (6, 5)	3 (0, 0)	0 (0, 0)	0 (0, 0)	14 (1, 7)
United States (133)	10 (0, 0)	3 (0, 0)	78 (1, 1.3)	0 (0, 0)	42 (0, 0)
Saudi Arabia (119)	24 (1, 4.2)	4 (0, 0)	35 (7, 20)	4 (0, 0)	52 (1, 1.9)
Poland (102)	2 (0, 0)	0 (0, 0)	9 (0, 0)	0 (0, 0)	91 (8, 9)
Greece (100)	71 (1, 1.4)	0 (0, 0)	26 (1, 3.8)	1 (0, 0)	2 (0, 0)
Cyprus (99)	0 (0, 0)	2 (0, 0)	95 (4, 4.2)	0 (0, 0)	2 (0, 0)
Ukraine (91)	77 (0, 0)	0 (0, 0)	13 (1, 7.7)	0 (0, 0)	1 (0, 0)
Austria (80)	2 (0, 0)	0 (0, 0)	8 (0, 0)	1 (0, 0)	69 (20, 29)
Australia (84)	21 (1, 4.8)	2 (0, 0)	21 (0, 0)	3 (0, 0)	37 (4, 11)
Lithuania (60)	26 (0, 0)	23 (0, 0)	2 (0, 0)	0 (0, 0)	9 (3, 33.3)
Philippines (57)	0 (0, 0)	0 (0, 0)	0 (0, 0)	4 (0, 0)	53 (0, 0)
United Kingdom (56)	17 (0, 0)	0 (0, 0)	34 (0, 0)	0 (0, 0)	5 (0, 0)
Morocco (50)	0 (0, 0)	0 (0, 0)	1 (0, 0)	0 (0, 0)	49 (23, 47)
Bulgaria (49)	23 (0, 0)	0 (0, 0)	14 (0, 0)	12 (1, 8.3)	0 (0, 0)
Denmark (44)	25 (0, 0)	10 (0, 0)	4 (0, 0)	0 (0, 0)	5 (0, 0)
Netherlands (33)	1 (0, 0)	0 (0, 0)	7 (0, 0)	0 (0, 0)	25 (0, 0)
Spain (33)	6 (0, 0)	1 (0, 0)	24 (0, 0)	2 (0, 0)	0 (0, 0)
Syria (31)	12 (4, 33.3)	1 (0, 0)	18 (7, 39)	0 (0, 0)	0 (0, 0)
Hungary (29)	1 (0, 0)	4 (0, 0)	15 (0, 0)	0 (0, 0)	9 (0, 0)
Lebanon (25)	10 (1, 10)	0 (0, 0)	13 (0, 0)	0 (0, 0)	2 (0, 0)
Belgium (23)	0 (0, 0)	0 (0, 0)	11 (0, 0)	0 (0, 0)	12 (9, 75)
Jordan (22)	8 (2, 25)	5 (0, 0)	5 (0, 0)	1 (0, 0)	3 (0, 0)
New Zealand (20)	0 (0, 0)	0 (0, 0)	10 (0, 0)	0 (0, 0)	10 (3, 30)
Romania (16)	2 (0, 0)	0 (0, 0)	0 (0, 100)	0 (0, 0)	14 (0, 0)
Bahrain (11)	0 (0, 0)	0 (0, 0)	0 (0, 0)	4 (0, 0)	7 (0, 0)
Oman (10)	1 (0, 0)	0 (0, 0)	1 (0, 0)	0 (0, 0)	8 (0, 0)
Iran (7)	5 (3, 60)	0 (0, 0)	1 (0, 0)	0 (0, 0)	1 (0, 0)
Canada (6)	6 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Serbia (6)	0 (0, 0)	0 (0, 0)	2 (0, 0)	0 (0, 0)	4 (0, 0)
Switzerland (5)	2 (0, 0)	0 (0, 0)	3 (0, 0)	0 (0, 0)	0 (0, 0)
Czech republic (4)	1 (0, 0)	0 (0, 0)	3 (0, 0)	0 (0, 0)	0 (0, 0)
Thailand (3)	2 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	1 (0, 0)
Bahrain (2)	0 (0, 0)	0 (0, 0)	0 (0, 0)	2 (2, 100)	0 (0, 0)
Bosnia (2)	2 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Japan (2)	0 (0, 0)	0 (0, 0)	1 (0, 0)	0 (0, 0)	1 (0, 0)
Sweden (2)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	2 (0, 0)
Mexico (1)	1 (1, 100)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Pakistan (1)	1 (1, 100)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Belarus (1)	0 (0, 0)	0 (0, 0)	1 (1, 100)	0 (0, 0)	0 (0, 0)
Ireland (1)	0 (0, 0)	0 (0, 0)	1 (1, 100)	0 (0, 0)	0 (0, 0)
Latvia (1)	0 (0, 0)	0 (0, 0)	1 (1, 100)	0 (0, 0)	0 (0, 0)
South Africa (1)	0 (0, 0)	0 (0, 0)	1 (1, 100)	0 (0, 0)	0 (0, 0)
Total	**1094 (67, 6.1)**	**121 (1, 0.8%)**	**987 (84, 8.5%)**	**74 (4, 5.4%)**	**1023 (129, 12.6.5%)**

[a] represents the total number of cheese samples originating from the mentioned country

[b] represents the total number of samples of each cheese type originating from the mentioned country

[c] represents the rejected samples from the total number of samples from this cheese type

[d] the percentage of non-conformity out of the total samples from this cheese type

at 14.3%. For processed cheeses ($n = 129$), 4 countries were shown to be the main sources of non-conformities. Egypt was responsible for 25.5%, Morocco had 17.8%, Austria had 15.5% and France had 10%.

Major nations exporting cheese to the UAE and the number of samples from each included in the present study are shown in Table 6. Among these countries, Turkey contributed the highest percentage of cumulative non-conformities (21.8%) with 83/380 samples non-compliant. According to Budak (2009), Turkey produces 12 billion litres of milk yearly, but more than 50% is distributed outside any structured quality control program, thus providing an undesirable significant opportunity for cheese contamination and human infection with milk-borne pathogens. Germany had the lowest level of non-conformities at 0.6%, and this was because of one of 159 samples (Table 6). This was likely the result of consistent monitoring of food legally shipped into the EU for serious risks and alerts generated. Non-conforming products are registered through the Rapid Alert System for Food and Feed (RASFF), and it is important to note that production locations in the EU are strictly controlled. A study conducted by Beutlich et al., (2015) found that 423 kg of foods of animal origin were confiscated from about 300 passengers following their arrival in Germany from 35 different countries. The majority of material confiscated (51%) originated from Turkey and Russia. Milk products represented 21% of the confiscated foods. In addition, Table 6 shows both the number and percent of non-compliant samples according to the country of production and type of cheese. Only data concerning soft cheeses, semi-hard cheeses and processed cheeses were analyzed since they represent the greatest number of samples. For soft cheeses, Egypt was found to be the main source, providing 230, of which 9 or 4% were non-conforming. Turkey was the second largest source of soft cheese ($n = 152$). For semi-hard cheeses, Italy was the main source of samples, being the supplier of 201 samples of which 12 or 6% were non-compliant. Turkey was the second largest source, and of 158 samples from Turkey analyzed, 49 or 31% did not conform with import requirements. For processed cheeses, Egypt was the main source of samples, and of 189 analyzed, 33 or 17% were shown to be non-compliant. France was also a major source, providing 145 samples of which 13 or 9% were non-conforming. Of 34 processed cheese samples from Turkey, 4 or 11.7% did not conform with regulations. This detailed analysis of the data has shown that Turkey was the main source of non-conformant imported cheese samples examined during the study.

Conclusion

This study aimed to determine the levels of compliance encountered during analysis of 3299 samples of perishable cheeses imported to the UAE over a 5-year period ending in 2021. Quality and safety criteria evaluated included the content of moisture and fat, acidity, presence of sorbic acid and a non-permitted colorant, quinoline, the occurrence of rust, along with a safety assessment through microbiological analyses. Of the cheese samples tested, 3014 conformed with UAE cheese standards; however, 285 were not compliant. Among the different types of cheese, processed cheese contained the highest percentage of non-conformity (13%), mainly due to high moisture and low-fat content. Thus, this could be of substantial value in predicting the probability of economic fraud. Since *E. coli* is used as a microbial quality indicator for food, its detectionin cheese may indicate unsanitary conditions and pathogen contamination. In the current study 85.7% of semi-hard cheese samples were non-compliant with respect to *E. coli.* This was the greatest frequency of non-compliance and was probably influenced by the high mean moisture content of 69.3% in these products. The country of origin of most non-conforming cheese was found to be Turkey, where 21.8% of violating samples had originated. Germany was found to have had 0.6% of total non-conformities which was the lowest proportion among importing countries. This latter was undoubtedly influenced by requirements that serious risk must be reported through RASFF. The current study emphasizes the need for improving compliance with hygienic standards for semi-hard and processed cheeses, particularlytheir high moisture levels to reduce hazards to health. This study highlights the importance of border inspection involving physicochemical analysis of cheese samples to regulate international trade, prohibiting the entry of food products likely to be adulterated, and fostering continued collaboration between importing and exporting countries to ensure compliance with stringent hygiene practices.

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Authors' contributions
T.M.O conceptualized the study, was involved in supervision, project administration and writing – reviewing and editing. W.A.B.O, K.A.M and M.K.S were involved in formal analysis. F.S.B.B.M, V.G and W.S.B were involved in data curation. R.S.O and N.E.D wrote the manuscript – original draft. R.H reviewed and edited the manuscript.

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Availability of data and materials
The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
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Competing interests
The authors declare no conflict of interest.

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