Research Article

Estimating the Microbial Safety and Sensory Characteristics of Some Imported Dairy Products Retailed in the Egyptian Markets

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Abstract | Intensive dairy products' usage, recent growth of globalization and the widespread of international trade mandate the microbial evaluation of the imported dairy products. In the present study, ninety random samples of imported milk powder, labneh and cheddar cheese from New Zealand, Ireland, Turkey, Poland, Netherlands, European Union and Switzerland were collected from the Egyptian markets then were investigated organoleptically and microbiologically. The sensory evaluation revealed that the majority of the examined labneh and cheddar cheese got excellent and good scores, while 90 % of milk powder samples got good scores, based on the overall acceptability scale. The mean titratable acidity percentages of milk powder, labneh and cheddar cheese samples were 0.169 ± 0.018, 0.935 ± 0.046 and 0.197 ± 0.013, respectively. Microbiological examinations revealed that all the examined samples were highly contaminated with aerobic mesophilic bacteria observed in milk powder and cheddar cheese with non-significant difference (p=0.408). Aerobic spore formers were recovered from in 50%, 66.67% and 86.67% of the tested samples with a significant difference between the mean count of milk powder and that of labneh and cheddar cheese (P> 0.05). 66.67% of milk powder samples were contaminated with coliforms, followed by cheddar cheese (43.33%) and labneh (23.33%), *E. coli* could be isolated from milk powder samples, while Salmonella species couldn't be detected in any of the examined samples. *Staphylococci* were recovered from most of the examined milk powder (83.33%), cheddar cheese (93.33%), and nearly half of the examined labneh (46.67%) samples, with non-significant differences between that of milk powder and labneh (p=0.572), and cheddar cheese (p=0.345). the majority of cheddar cheese (83.33%) and labneh (63.33%) samples were contaminated with yeast and mold. Additionally, proteolytic and lipolytic organisms were present nearly in most of the examined samples, which resulted in lowering the flavor and texture scores of the tested products. Finally, public awareness targeting the imported companies and good hygienic practices should be fullfilled during handling, packaging, storage and distribution.

Keywords | Milk powder, Labneh, Cheddar cheese, Microbial examination, Sensory characteristics, *E. coli*

Received | July 29, 2021; **Accepted** | October 24, 2021; **Published** | January 15, 2022
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Citation | Halim EYA, El-Essawy H, Awad AAN, El-Kutry MS, Ahmed LI (2022). Estimating the microbial safety and sensory characteristics of some imported dairy products retailed in the Egyptian markets. Adv. Anim. Vet. Sci. 10(3): 488-499.
DOI | http://dx.doi.org/10.17582/journal.aavs/2022/10.3.488.499
ISSN (Online) | 2307-8316;

INTRODUCTION

Because of the low milk production in many developing countries, using of imported milk powder has been increased. Milk powder has a better keeping quality, a less storage space, and low shipping costs, in contrast to the liquid milk. Furthermore, it is involved in the processing of cheese, yoghurt, custard, pudding, ice cream, and the other milk based food preparation, in addition to its use in infant milk based formulae. Consequently, dried milk powder should be of high sensory, nutritional and microbiological quality (Robert et al., 2015). Labneh (Concentrated

yogurt) is a semisolid fermented dairy food produced by removing a part of the whey from yoghurt to reach total solid levels between 23 and 25 g/100 g. It is one of the most favorable dairy products in the Middle East, and has gained immense popularity owing to its higher nutritional value compared with traditional yoghurt, in addition to the better taste and texture (Yeganehzad et al., 2007; Ahmed et al., 2014). Cheddar Cheese which is made of pasteurized milk of low pH, elevated salt concentration and low water activity; however, microbial contamination can occur during its ripening period or in the distribution chain even under refrigerated storage (Al-Groom, 2017).

Recent growth of globalization with the extensive spread of international trade, give the dairy companies the opportunities for distributing their products worldwide and the consumers the chance to choose among many products made in different countries. Consequently, country of origin has become a vital part in customers' purchase decision-making process and its effect has been extensively studied (Aichner, 2014; Balabanis and Siamagka, 2017), in addition to measuring the hygienic quality parameters of these imported products.

The hygienic quality parameters used for evaluating the milk products are the microbiological quality, sensory characteristics, and the physicochemical properties. Microbial quality is affected by the initial flora of the used raw milk, processing, distribution and storage conditions and the post-heat treatment contamination especially in case of milk powder subjected to lethal temperatures during its processing. Insufficient hygienic practices could result in contamination with pathogenic bacteria and fungi (Ahmed et al., 2020, 2021).

Undesirable microbes contaminating milk and milk products are Gram-negative psychrotrophs, coliforms, aerobic spore formers, yeast, and mold. Moreover, microbial pathogens of major concern such as Salmonellae, *Bacillus cereus* and *S. aureus* have been implicated in a number of food-borne outbreaks via dried milk powders consumption; while these organisms don't grow in the powder, they may remain viable for long periods of time and resume growth when the powder is reconstituted and stored at favorable temperature (Hafsa et al., 2013). Furthermore, cheese has been a food vector for *S. aureus* foodborne outbreaks (CDC, 2015). Recently, six *S. aureus* outbreaks occurred in France owing to consumption of soft cheese contaminated with enterotoxin type E (Ostyn et al., 2010).

In addition to the safety issue, people are becoming more and more aware about the quality of dairy products. Sensory evaluation is the simplest, most rapid, and direct approach for judging the quality as well as the sensory defects of the dairy, it includes the color, taste, flavor and general appearance of the product (Grunert, 1995; Clark et al., 2009; Ahmed, 2016). While purchasing dairy food, sensory appeals were the most important motivational feature by many consumers who take taste, freshness and naturalness into consideration (Markovina et al., 2015; Roman et al., 2017).

Governments started to pay much more attention to the safety of the dairy products than before. They adopted a comprehensive food safety standards and certification system to improve the domestic dairy products safety and to restore the consumer confidence toward the consumed milk and milk products (Ahmed, 2016).

Therefore, the present study delivered the laboratory evaluation of the imported dairy products retailed in the Egyptian markets in terms of microbial safety and sensory characteristics. It focused on milk powder, labneh and cheddar cheese imported from New Zealand, Ireland, Turkey, Poland, Netherlands (Holland), European Union and Switzerland. The obtained results were compared with the Egyptian specification.

MATERIALS AND METHODS

Collection of samples

Ninety random samples of full cream milk powder, Labneh and cheddar cheese [thirty of each] imported from different origins; New Zealand, Ireland, turkey, Poland, Netherlands (Holland), European Union and Switzerland collected from dairy shops and supermarkets in Cairo, Giza and Qalubya governorates in Egypt and transferred to the laboratory of microbiology of food hygiene and control department in an insulating ice-box with a minimum of delay to be immediately examined.

Organoleptic inspection

Organoleptic examination was determined according to USDA score card. Sensory evaluation of milk powder and cheddar cheese were determined according to Nelson and Trout (1981), for the; container, closure (physical state of package) (5 points), appearance (5 points), flavor (40 points), body and texture (40 points), color (10 points) and Salt (5 points). While, sensory properties of labneh were estimated according to Clark et al. (2009).

Determination of the titratable acidity percentage

Titratable acidity percentages of labneh and milk powder samples were measured according to APHA (2004), while that of cheddar cheese was determined according to AOAC (2000).

Microbiological examination

Total aerobic mesophilic count was applied according to

ISO (2002). 1 ml of the previously prepared tenfold serial dilution was dispensed onto duplicate plates of plate count agar and incubated at 30± 1˚C for 72 hours.

Aerobic spore formers testing was done according to APHA (2004). The homogenate was heated in a water bath at 80±1˚C for 12 minutes, and suddenly cooled in an ice bath before the decimal dilutions were prepared. 1 ml was dispensed onto duplicate plates of plate count agar and incubated at 32± 1˚C for 48 hours for mesophilic spore formers detection. Identification of the isolated aerobic spore formers was applied according to De Vos et al. (2009).

Coliform content (MPN/g) was estimated according to APHA (2004). The isolated coliforms were biochemically identified according to De Vos et al. (2009). Molecular identification of the isolated *E. coli* by polymerase chain reaction (PCR) for 16S rRNA gene by ECO-1, F (ACCTCGGTTTAGTTCACAGA) and ECO-2 R (ACACGCTGACGCTGACCA) specific primers according to the standard procedure conducted by Schippa et al. (2010) with suspected products at 585bp.

Isolation and identification of *Salmonella* species was applied according to APHA (2004).

Total *Staphylococci* count, in addition to its biochemical identification was assessed according to APHA (2004). 0.1 ml was spreaded onto the dry surface of duplicate plates of Baired-Parker medium supplemented with egg yolk tellurite and incubated at 35˚C for 24-48 hours.

Total Yeast and Mold count was assessed according to ISO (2012). Duplicate plates of malt extract agar were inoculated with 0.1 ml of the previously prepared tenfold serial dilutions an incubated at 25˚C for 3-5 days.

Proteolytic and Lipolytic microorganisms count was applied according to APHA (2004). Duplicate plates of standard caseinate agar and Spirit blue agar were inoculated with 0.1 ml. from the previously prepared serial dilutions and incubated at 32 ±1˚C for 48-72 hours.

Statistical analysis

Results were calculated in the form of mean ± SEM. The comparison between the microbial quality of the tested products using Kruskal-Wallis test and Mann-Whitney U test was assessed using Statistical Package for the Social Sciences (SPSS) software, version 20. Value of $P< 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

Sensory properties of the examined samples

The data recorded in Table 1 revealed that about 43.3 and 40 % of the examined labneh and cheddar cheese were excellent, while, 50 and 56.7 % were good, respectively, while the majority of milk powder samples were good (90%), based on the overall acceptability scale. Although the microbial quality, shelf life, and shelf stability remain as key methods for defining the high-quality dairy products; flavor is another way to define the milk quality (Ahmed, 2016). About 86.7, 30 and 23.3 % of the examined milk powder, labneh and cheddar cheese samples had good flavor scores, respectively, with 10% of the tested milk powder scored excellent flavor. The container and the closure score of most examined milk powder (73.3%) and labneh (53.3 %) was good. All the tested milk powder samples had excellent appearance and the majority of cheddar cheese had fair and poor texture (Figure 1).

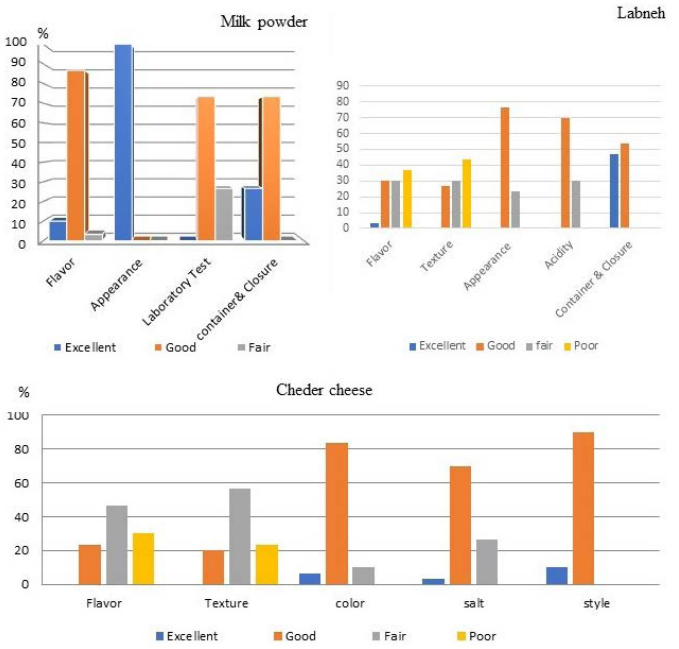

Figure 1: Grading of the examined sample based on their sensory properties.

The lower scores may be attributed to the inappropriate storage conditions and the contaminating bacteria which proved their presence via the microbiological contamination. These bacteria produce undesirable flavor and aroma compounds significantly limit the product's organoleptic quality. The organoleptic changes become detectable at a bacterial count of 10^6 cfu/g or more (Clark et al., 2009). Moreover, unfavorable changes in milk powder might be attributed to the presence of thermos-stable bacterial lipases and proteases that can withstand the extreme heat treatment of milk powder processing and during storage; they release free fatty acids which give a rancid off-flavor, and peptides that give a bitter taste (Simon and Hansen, 2001; Chen et al., 2003).

The low score of labneh samples could be assigned to the over acidic taste and soft texture, in addition to the color

defects noticed while examining the product. However, it was characterized by good to excellent container and closure which protects the product against the contamination with dirt, insects, microorganisms, and light. The Fermented product should have a glossy to a semi-glossy and velvety appearance. The body and texture of a sufficiently ripened product before being shaken should be firm, solid, and uniform, showing not more than a few beads of whey exuded from its surface (Clark et al., 2009; Ahmed, 2016).

Concerning cheddar cheese, the hard textures of some examined samples, in addition to the foreign and flat flavor were the causes of their low scores. On the other hand, the majority had a good color and style. The overall high score of cheese acceptability was reported by Abd El-Galeel et al. (2017), while lower results were recorded by Karima (2012), Thoraya (2013) and Ahmed (2016). Additionally, Ibrahim et al. (2021) draw back the fair and poor quality of milk powder to the cooked flavor that was the most frequent off-flavors noticed.

Titratable acidity percentage

The dairy products freshness, the bacterial activity in milk, the bacterial contamination, and the storage temperature are the main key elements influencing the acid formation. Decreasing milk pH from 6.8 to less than 4.6, protects the fermented dairy products such as cheese and labneh from the risk of contamination by pathogens and renders them hygienically safe (Mohamed et al., 2020).

The mean titratable acidity percentages of the examined milk powder, labneh and cheddar cheese samples were 0.169±0.018, 0.935±0.046 and 0.197±0.013, with the presence of significant differences between the mean acidity % of milk powder and that of labneh and cheddar cheese, in addition to presence of a significant difference between labneh and cheddar cheese (P>0.05). Additionally, according to the Egyptian Standards, the titratable acidity percentages of all the examined milk powder and labneh were agreed with the Egyptian standards (EOS, 2005b, 2006) (1648/2005; 3157/2006) (Tables 2 and 3).

By comparing our results with the previous studies, Salama (2015) and Ahmad (2017) reported higher Titratable acidity % in labneh samples with mean values of 1.934 and1.76 %, respectively, while nearly similar results were obtained by Ahmed et al. (2014) who recorded mean titratable acidity % of 1.08 ± 0.07. Regarding cheddar cheese, the obtained results were lower than that reported by Abdelmagid and Hamid (2018) and Mohamed et al. (2020) who reported mean titratable acidity % of 0.43±0.02. Additionally, Abdelkhalek et al. (2016) and Ibrahim et al. (2021) recorded a higher mean titratable acidity % of 0.99 in milk powder samples, whereas Nissreen (2006) and Kajal et al. (2012) estimated nearly similar results with mean titratable acidity % of 0.13.

Cheddar cheese and labneh samples are normally considered safe against the food borne diseases because of their low pH, in addition to the antimicrobial compounds such as bacteriocins, formic acid, hydrogen peroxide, acetate, and diacetyl that produced by the used starter cultures (Ahmed et al., 2020).

Aerobic mesophilic count

Standard plate count is one of the prevalent methods used all over the world for assessing the overall quality and safety of food. Moreover, it is a useful indicator for monitoring the sanitary conditions applied during the production, collection, and handling of milk and dairy products (Ahmed, 2016; Ahmed et al., 2020).

All the examined samples were contaminated with aerobic mesophilic microorganisms with high counts observed in the examined milk powder and labneh with mean counts of 28.15 $X10^7$± 23.4 $X10^7$and 12.02 ×10^5±4.85× 10^5cfu/g, respectively, with non-significant difference (p=0.408). While the mean count in the examined cheddar cheese samples was 55.5×10^5±10.16×10^5cfu/g with the presence of significant differences with that of milk powder and cheddar cheese (P> 0.05) (Table 2).

Table 1: Grading of the examined samples based on their overall acceptability.

Score	Grade	Milk powder		Labneh		Cheddar cheese	
		No.	%	No.	%	No.	%
> 90 %	A (Excellent)	3	10.0	13.0	43.3	12.0	40.0
80-90 %	B (Good)	27.0	90.0	15.0	50.0	17.0	56.67
60 - 80 %	C (Fair)	0.0	0.0	2.0	6.7	1.0	3.33
Total		30.0	100.0	30.0	100.0	30.0	100.0
> 90 %	A (Excellent)	3	10.0	13.0	43.3	12.0	40.0
80-90 %	B (Good)	27.0	90.0	15.0	50.0	17.0	56.67
60 - 80 %	C (Fair)	0.0	0.0	2.0	6.7	1.0	3.33

Table 2: Statistical analytical results of the tested parameters of the examined samples (n=30).

Parameters	Total no. of samples	% Positive samples	Min.	Max.	Mean ± SEM	Kruskal Wallis test mann whitney U test (p value)
Titratable acidity %	Milk powder (G1)	100	0.09	0.36	0.169 ± 0.018	G1,2 (0.00) G1,3 (0.025) G 2,3 (0.00)
	Labneh (G2)	100	0.70	1.40	0.935 ± 0.046	
	Cheddar cheese (G3)	100	0.07	0.36	0.197 ± 0.013	
Total aerobic mesophilic count (cfu/g)	Milk powder	100	10^2	7.04×10^9	$28.15\ X10^7\pm 23.4\ X10^7$	G1,2 (0.001) G2,3 (0.00) G1,3 (0.408)
	Labneh	100	10^4	1.08×10^7	$12.02\times10^5 \pm 4.85\times 10^5$	
	Cheddar cheese	100	11×10^4	24×10^6	$55.5\times10^5 \pm 10.16\times10^5$	
Aerobic Spore Formers (cfu/g)	Milk powder	50	$2\ X10^2$	$2\ X10^4$	$46.5\times10^2\pm 14.96\ x10^2$	G1,2 (0.00) G1,3 (0.00)
	Labneh	66.67	10^4	$73\ X10^4$	$14.35\times10^4\pm 4.775x10^4$	
	Cheddar cheese	86.67	10^3	12×10^5	$25.4\times10^4\pm7.958x10^4$	
Coliform count (MPN/g)	Milk powder	66.67	$4\ X10^5$	15×10^9	$28.74X10^8\pm10.557X10^8$	G1,2 (0.00) G1,3 (0.001) G2,3 (0.067)
	Labneh	23.33	$3\ X10^4$	$11\ X10^6$	$22.6\times10^5\ \pm15.1\times10^5$	
	Cheddar cheese	43.33	4×10^5	46×10^6	$13.13\times10^6 \pm 4.59\times10^6$	
Total Staphylococci count (cfu/g)	Milk powder	83.33	50.0	2.76×10^8	$18.38\times 10^6\pm11.52x10^6$	G1,2 (0.572) G1,3 (0.345) G2,3 (0.00)
	Labneh	46.67	10^4	56×10^4	$13.71\times10^4\pm5.236\times10^4$	
	Cheddar cheese	93.33	2×10^4	3×10^6	$72.32\times10^4\pm16.36\times10^4$	
Total yeast count (cfu/g)	Milk powder	33.33	10^2	$2\ X10^4$	$3.09\times10^3\pm 1.96x10^3$	G1,2 (0.016) G1,3 (0.00) G2,3(0.009)
	Labneh	36.67	10^3	$14.6\ X10^4$	$32.18\times10^3\pm14.6\times10^3$	
	Cheddar cheese	70	10^3	$2\ X10^6$	$31.43\times10^4\pm11.75\times10^4$	
Total mold count (cfu/g)	Milk powder	30	50	$9\ X10^3$	$12.16\times10^2\pm9.74\times10^2$	G1,2 (0.001) G1,3 (0.00) G2,3 (0.00)
	Labneh	46.67	10^3	$8\ X10^3$	$27.85\times10^2\pm5.66\times10^2$	
	Cheddar cheese	30	10^3	$9\ X10^4$	$18\times10^3\pm9.19\times10^3$	
Total yeast & mold count (cfu/g)	Milk powder	40	50.00	$29\ X10^3$	$34.92\times10^2\pm9\times10^2$	
	Labneh	63.33	10^3	$14.6\ X10^4$	$20.58\times10^3\pm0.9\times10^3$	
	Cheddar cheese	83.33	10^3	$20.1\ X10^5$	$27.1\times10^4\pm0.09\times10^4$	
Proteolytic count (cfu/g)	Milk powder	90	$9\ X10^2$	$42.8\ X10^4$	$31.19\times10^3\pm16.7\times10^3$	G1,2 (0.730) G1,3 (0.00) G2.3 (0.00)
	Labneh	96.67	10^3	$6\ X10^4$	$11.21\times10^3\pm2.45\times10^3$	
	Cheddar cheese	93.33	10^3	$3\ X10^6$	$56.18\times10^4\pm15.44\times10^4$	
Lipolytic count (cfu/g)	Milk powder	60	$8\ X10^2$	$14.6\ X10^4$	$16.17\times 10^3\pm8.27\times10^3$	G1,2 (0.016 G1,3 (0.001) G2,3 (0.257)
	Labneh	60	10^3	$42.3\ X10^4$	$78.44\times10^3\pm30.06\times10^3$	
	Cheddar cheese	70	10^3	$48.4\ X10^5$	$54.92\times10^4\pm27\times10^4$	

Significant results were obtained at $P> 0.05$

Table 3: Compatibility of the examined samples with the Egyptian standards.

	Normal parameters	Milk powder ES: 1648/2005	Labneh ES:3157/2006	Cheddar cheese 2005/2-1007
Acidity %	1.2 (Milk powder) 2.5 (Labneh)	100	100	-
TBC Count	10^4 cfu/g (Milk Powder)	10.0	-	-
Coliforms	10MPN/g	30.0	83.33	56.66
E. coli	Nil	87.5	100	100
S. aureus	Nil	42.86	77.78	60.72
Salmonella spp.	Nil	100	100	100
Yeast counts	100 cfu/g (Cheddar cheese) Nil (Labneh)	-	63.33	30
Mold counts	10 (Cheddar cheese) Nil (Labneh)	-	53.33	70
Total yeast and mold	10 cfu/g (Milk powder)	60	-	-
ASF (United States Dairy Export Council) (USDEC) (Milk powder)	less than 1000 cfu/g (Milk powder)	53.33	-	-

The high water activity, available nutrients and moderate pH, made milk a suitable medium for the microbial growth. The most significant source of milk contamination is the utensils and milk contact surfaces, including milk pails, and machines, in addition to the contamination during manufacturing processes, transportation, and storage. Therefore, it is necessary to maintain high standards of hygiene during manufacturing processes (Kolita, 2010).

About 90% of the tested milk powder samples exceeded the Egyptian standards (1648/2005). The high bacterial count mirrored the poor hygienic practice applied during manufacturing, packaging and/or storage. These high counts resulted in poor-quality products with lowering of the overall sensory acceptability score, especially those of fermented products that have low pH protecting them from the risk of contamination and consequently, should not give this high microbial incidence.

The obtained results of labneh were higher than that obtained by Saleh (2013) and Ahmad (2017) who reported mean count of 5.72 Log_{10} and 6.5 x 10^3 cfu/g, respectively, while nearly similar results were recorded by Salama (2015) who found that the mean aerobic mesophilic count was $3.18x10^5 \pm 6.1x10^4$. On the other hand, the obtained results of cheddar cheese were lower than that reported by Karima (2012) and Mohamed et al. (2020) who recorded mean counts of 2.39×10^{10} and 7.3×10^4 cfu/g, respectively. While the results of milk powder, were higher than that obtained by El-Etriby (2017) who stated that the mean count was $2.1\times10^3\pm0.12\times10^3$ and Ibrahim et al. (2021) who reported mean count of $4.97\times10^2\pm1.21\times10^2$cfu/g.

This high bacterial load is an indicator of recontamination. Because the imported dairy products always comply with universal standards, no bacterial growth will be observed during and after processing. The recontamination could be resulted from the resistance of spore forming bacteria to the heating process, unhygienic storage condition, post heat treatment contamination and/or defected packaging, bad handling and the bad personnel hygiene. Furthermore, after manufacturing of milk powder, it is imported to Africa via sea freight containers then, bulk packed in China and Europe, then re-packed into small packages and distributed in many African countries. The exposure of these products to, the tropical conditions, high levels of relative humidity and temperature during their transportation and storage, influence the stability of the powder in addition to the possible contamination during the repacking process in case of lacking of the hygienic practice applied (Thomas et al., 2004; Ahmed et al., 2014, 2020).

Aerobic spore formers (ASF)

ASF were present in 50%, 66.7% and 86.7% of the tested milk powder, labneh and cheddar cheese with mean counts of $46.5\times10^2\pm14.96$ x10^2, $14.35\times10^4 \pm 4.775x10^4$ and $25.4\times10^4\pm7.958x10^4$ cfu/g, respectively, with a significant difference between the mean count in milk powder and that of labneh and cheddar cheese (P>0.05) (Table 2). The biochemical identification of aerobic spore former isolates of milk powder samples revealed that Sporosarcina was the most frequent bacteria (35.71%), followed by *Sporolactobacillus* and *Bacillus licheniformis* (21.42% each), while in labneh samples; *Sporosarcina* was the most frequent (50%), followed by *Sporolactobacillus* (35%), then *B. alvei, B. megaterium and B. licheniformis* (5%). Regarding cheddar cheese; *Sporosarcina* (51.9%) was the most frequent, followed by *Sporolactobacillus* (33.3%) and *B. megaterium* (11.1%), then *B. cereus* (3.7%) (Figure 2).

Figure 2: The incidence of the isolated microbial strains in the examined samples.

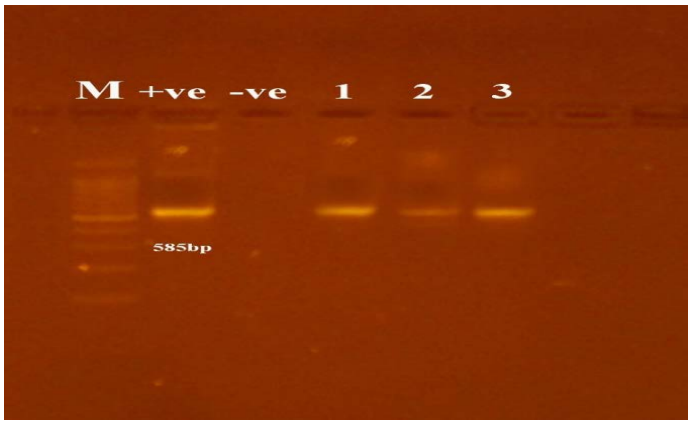

Figure 3: Agarose gel electrophoresis showing positive amplification for *E. coli* 16s rRNA gene at 585 bp.

Milk and milk products quality are monitored by many

microbiological criteria related to the spore-forming bacteria. The United States Dairy Export Council recommended that mesophilic spore formers should be less than 1000 cfu/g in milk powder (Watterson et al., 2014). Accordingly, only 53.33% of the examined milk powder was in accordance with this specification.

Aerobic spore formers presence in the examined milk products could result from the occurrence of spore-forming bacteria in raw milk (Gupta and Brightwell, 2017; Masiello et al., 2017). Its presence is of a great importance, because of the public health hazards of some of them such as *B. cereus*, *B. subtilis, B. pumilus* and *B. megaterium* which have been involved in food poisoning and gastrointestinal disorders (Ahmed, 2016). On the other hand, they are considered of economic importance, owing to the extracellular heat stable proteinase as well as the lipases enzymes that cause adverse changes reducing the products quality or even making them unmarketable (Ahmed, 2016).

When comparing our labneh results with the previous studies; Ahmed et al. (2014) reported higher mean count of ASF ($20\times10^4 \pm 38.8\times10^3$ cfu/g). Higher results of milk powder were estimated by Li et al. (2019) who recorded maximum ASF count of 2.13 log cfu mL1.

B. cereus could be detected in cheddar cheese samples. One or two types of toxins can be produced by some strains of *B. cereus* and, very rarely, *B. subtilis* and *B. licheniformis*: Emetic heat stable toxin that is produce in foods and the diarrheagenic toxin which excreted during the microbial growth in the gastrointestinal tract (Pal et al., 2014; Freedman et al., 2016). Nevertheless, there are some reports confirming the production of toxins from some strains of *B. licheniformis, B. circulans, B. pumilus, B. lentus, B. subtilis, B. brevis,* and *B. megaterium* (Yoo et al., 2014).

Coliforms

The milk powder samples were the most contaminated product with coliforms (66.67%), followed by cheddar cheese (43.33%), while labneh was the lowest contaminated product (23.33%), with mean value of $28.74X10^8 \pm 10.557X10^8$, $13.13\times10^6\pm4.59\times10^6$ and $22.6\times10^5\pm15.1\times10^5$ MPN/g, respectively. There was significant differences between the mean coliform counts of the different products ($P>0.05$) (Table 2). The biochemical identification of coliforms in the examined milk powder samples revealed that *Enterobacter intermedius* (37.5%) was the most common bacteria followed by *Citrobacter freundii* (29.16%), *E. coli* (12.5%), and *Citrobacter diversus* (12.5%). The presence of *E. coli* was confirmed using the molecular identification by polymerase chain reaction (PCR) that showed positive amplification for *E. coli* 16s rRNA gene at 585 bp (Fig. 3). There were three coliform stains (*Citrobacter freundii*) isolated from the positive labneh samples. While biochemical identification of the isolated coliforms from cheddar cheese revealed that *Citrobacter freundii* (42.85%) and *Enterobacter intermedius* (42.85%) were the most frequent followed by *Citrobacter diversus* (14.28%) (Figure 2).

Because of the easily killing of coliform organisms by pasteurization, it can be used as a pointer of the post heat treatment contamination (Ahmed et al., 2020). Coliforms could be detected in most of the examined milk powder samples and in some of the other samples with high counts since only about 30, 83.33 and 56.66 % of the examined milk powder, labneh and cheddar cheese were in accordance with the Egyptian standards (EOS, 2005a, b, 2006) (1648/2005; 3157/2006; 2-1007/2005). The high prevalence and count indicated the ignored sanitary measures, deficient heat processing or post pasteurization contamination by handlers. Concerning the high prevalence of milk powder contamination; lack of the sanitation practices during the repacking process, storage and distribution might be the cause. Furthermore, contamination of about 50 % of the examined cheddar cheese samples might cause 'Early blowing' defect which was described by the existence of large gas holes and a spongy texture causing economic losses.

The obtained results of coliform in milk powder and labneh were higher than that reported by Matin et al. (2019); Gavião et al. (2020) and Ibrahim et al. (2021) who reported counts less than 3 MPN/g. While, lower results of cheddar cheese were recorded by Abdelmagid and Hamid (2018) and Mohamed et al. (2020) who found that the mean coliform count was $7.3\times10^4 \pm3.9\times10^4$mpn/g.

E. coli could be isolated only from milk powder samples and this was in accordance with Abdelkhalek et al. (2016) and Matin et al. (2019). Presence of *E. coli* refers to fecal contamination since about 0.1% of the gut microbiota is *E. coli* with other facultative anaerobes (Eckburg et al., 2005; Ahmed et al., 2021). Most *E. coli* strains are mild; however, some serotypes such as Enteropathogenic *E. coli* can cause significant food poisoning which is characterized by infantile diarrhea and gastroenteritis in adults (WHO, 2008).

Additionally, the presence of *E. coli* may be associated with the occurrence of other enteric pathogens (Nazir et al., 2005). Fortunately, *Salmonella* species couldn't be detected in any of the examined samples despite of the presence of *E. coli*. Similar results were recorded by Abdelkhalek et al. (2016) and Ibrahim et al. (2021).

Total *Staphylococci* and *Staphylococcus aureus*

Staphylococci were present in most of the examined milk

powder samples (83.33%), cheddar cheese (93.33%), and nearly half of the examined labneh (46.67%) with mean counts of 18.38×10^6 $\pm11.52x10^6$, $72.32\times10^4\pm16.36\times10^4$ and $13.71\times10^4\pm5.236\times10^4$ cfu/g, respectively, with non-significant differences between the milk powder and labneh (p=0.572), and milk powder and cheddar cheese (p=0.345) (Table 2). The highest incidence of *S. aureus* was assessed in milk powder (57.14%) compared to cheddar cheese (39.28%) and labneh (22.22) depending on the results of the coagulase test and TNase test (Figure 2). Most of the examined milk powder and cheddar cheese, and nearly half of labneh samples were contaminated with *staphylococci* which could be attributed to the presence of the genus on nose, hands and skin of the handlers, therefore, the poor hygienic practices, personal hygiene and the lack or inefficient hand washing may be the main causes of these high prevalence and counts. Additionally, *S. aureus* is salt tolerant and can grow aerobically at water activity 0.83, so, its presence in dried food is relevant (Blagoeva et al., 2014). Heat-resistant enterotoxins are produced when *S. aureus* count exceeds 5 Log cfu/g with subsequent food poisoning intoxication occurred when 20 -1,000 ng enterotoxins were ingested, the enterotoxins are emetic, mitogenic and pyrogenic (CDC, 2010; Soliman and Ahmed, 2019).

Labneh outcomes were higher than that reported by Gavião et al. (2020) who recorded a mean count of 1.33 ± 0.44 log cfu/g, while Khalaileh et al. (2019) couldn't detect their presence in the examined labneh samples. On the other hand, cheese results were lower than that obtained by Mohamed et al. (2020) who reported a mean count of 5.9×10^6 $\pm3.6\times10^6$ cfu/g. Additionally, Abdelkhalek et al. (2016) and Ibrahim et al (2021) recorded lower results of *Staphylococci* in milk powder with a mean value of 0.94×10^2 $\pm0.21\times10^2$cfu/g.

Yeast count

Cheddar cheese was the highest contaminated product with yeast (70%) compared to milk powder (33.33%) and labneh (36.67%), with mean counts of $3.09\times10^3\pm1.96x10^3$, $32.18\times10^3\pm14.6\times10$ and 31.43×10^4 $\pm11.75\times10^4$ cfu/g, for milk powder, labneh and cheddar cheese, respectively. Additionally, about 63.33% and 30 % of the examined labneh and cheddar cheese were in accordance with the Egyptian standard. The high level of yeast contamination in the examined samples may be attributed to the inadequate hygienic measures during production or the use of bad quality raw materials, in addition to the bad transportation and/ or storage condition (Ahmed et al., 2014, 2020). Yeast contaminates the dairy products causing economic losses owing to the produced undesirable changes such as frothy consistency and yeasty flavor. Moreover, some species of yeast represent a public health hazard, such as gastrointestinal disturbance, endocarditis, and occasionally fatal systemic diseases (Ahmed et al., 2014, 2020). The obtained results of cheddar cheese were higher than that obtained by El-Leboudy et al. (2015) who reported mean total yeast count of $1.16\ x10^5 \pm 4.24\ x\ 10^4$cfu/g, while lower than that mentioned by Mohamed et al. (2020) who found that the mean count was 7.7×10^8 $\pm5.09\times10^8$cfu/g. On the other hand, labneh results were lower than that reported by Ahmed et al. (2014) who recorded mean count of 42.1×10^3 $\pm26.4\times10^2$ cfu/g. Concerning milk powder; lower findings were recorded by Ibrahim et al. (2021) who found the mean yeast count was 0.65×10^2 ± 0.05×10^2 cfu/g, while nearly similar results were assessed by Nissreen (2006).

Mold count

Whereas mold was present in 30%, 46.67% and 30% of the examined milk powder, labneh and cheddar cheese, with mean counts of $12.16\times10^2\pm9.74\times10^2$, 27.85×10^2 $\pm5.66\times10^2$and 18×10^3 $\pm9.19\times10^3$ cfu/g, respectively, with presence of significant differences between the examined products (P>0.05). The highest mean count for total yeast and mold was $27.05\times10^4\pm9\times10^2$ in cheddar cheese, followed by labneh (20.58×10^3 $\pm9\times10^2$), then milk powder (34.92×10^2 $\pm9\times10^2$ cfu/g) (Table 2).

Labneh was the highest contaminated samples with mold (46.67%) compared to the other evaluated products owing to their acidic condition that favor the growth of fungi. This type of contamination causes serious economic losses because it is associated with visible spoilage signs such as off flavor and discoloration that resulted in product rejection, with the probability of presence of mycotoxins which implicated in human food poisoning outbreaks (Ahmed et al., 2020).

Mold count outcomes in cheddar cheese were lower than those estimated by Abdel-Salam and Soliman (2019) and Mohamed et al. (2020) who reported a mean mold count of 7.1×10^4 $\pm6.7\times10^4$ cfu/g. The reported labneh result was lower than that recorded by Ahmed et al. (2014) who found that the mean mold count was 21.2×10^3 ± 61.1×10^2 cfu/g. Lower results in milk powder were recorded by Ibrahim et al. (2021) who reported a count of >10 cfu/g, while nearly similar results were assessed by Nissreen (2006).

According to the Egyptian standards (EOS, 2005a, b; 2006) (2005/1648), (2006/3157) and (2005/2-1007), 53.33 and 70% of the examined labneh and cheddar cheese, respectively, were in agreement with the Egyptian standards for total mold count, while 60% of the tested milk powder was in accordance for total yeast and mold count (Table 3).

Proteolytic count

It was clear that proteolytic organisms were present

in 90%, 96.67% and 93.33% of the examined milk powder, labneh and cheddar cheese, with mean counts of 31.19×10^3 $\pm16.7\times10^3$, $11.21\times10^3 \pm 2.45\times10^3$ and $56.18\times10^4 \pm 15.44\times10^4$cfu/g, respectively, with non-significant difference between milk powder and labneh (p=0.730) (Table 2).

It was cleare that proteolytic count in cheddar cheese samples was lower than that obtained by Karima (2012) and Abdel-Salam and Soliman (2019) who reported a mean count of $5.8 \times 10^{10} \pm 4.5 \times 10^{10}$cfu/g. Higher count in milk powder was recorded by Majeed et al. (2005) who showed an average count of 3.2 × 10 cfu/g, while nearly similar results were assessed by Nissreen (2006). On the other hand, Aziz (2011) could detect proteolytic organism at different storage time of labneh. Proteolytic bacteria can degrade the casein protein into peptides that induce abnormal bitter flavor to milk and dairy products even though they are kept refrigerated, because most of them belongs to the psychrophilic and psychrotrophic groups that can grow at the cold storage (Ahmed, 2016). Additionally, *Bacillus* species have higher extracellular and intracellular proteolytic activity as compared with any other (Contesini et al., 2018).

Lipolytic count

Extracellular lipase enzyme is produced by the psychrophilic bacteria like *Pseudomonas*, *Enterobacter*, *Alcaligenes* and some spore-formers. It is concentrated in the manufactured milk products through its adsorbtion on the milk fat globules causing hydrolysis of triglycerides of the short chain fatty acids, including butyric, caproic, caprylic, and capric acids resulting in unpleasant odors in milk and rancidity in the dairy product (Chen et al., 2003; Dogan and Boor, 2003; Ahmed, 2016)

Lipolytic organisms were present in 60%, 60% and 70% of the examined milk powder, labneh and cheddar cheese, with mean counts of $16.17\times 10^3 \pm 8.27\times10^3$, $78.44\times10^3 \pm 30.06\times10^3$ and $54.92\times10^4 \pm 27\times10^4$cfu/g, respectively, with non-significant differences between labneh and cheddar cheese (p=0.257) (Table 2).

The recorded results of milk powder were higher than that estimated by Majeed et al.(2005) who reported an average count of 19 × 10 cfu/g, while nearly similar to that assessed by Nissreen (2006). Cheese result was lower than that provided by Abdel-Salam and Soliman (2019) who reported a mean count of $3.0 \times 10^8 \pm 1.2 \times 10^8$cfu/g. On other hand, Aziz (2011) could not detect lipolytic organisms in labneh.

The presence of the proteolytic and lipolytic organisms might be the cause of the low flavor scores during the sensory examination of the tested products. Therefore, establishment of an efficient program for the assurance of high quality whole milk powder, sanitary re-packaging retails and frequent examination of the repacked milk powder and the other imported products is essential.

CONCLUSIONS AND RECOMMENDATIONS

By examining the hygienic quality and sensory characteristics of the imported milk powder, labneh and cheddar cheese samples retailed in the Egyptian markets; the majority of the examined samples got excellent and good scores in relation to the over acceptability scale. Microbiological examination of the tested samples revealed a higher contamination level of milk powder in comparison to the examined labneh and cheddar cheese, in addition to the isolation of pathogenic *E. coli* from milk powder samples with the presence of high numbers of contaminated aerobic mesophilic microorganisms, coliforms, aerobic spore formers, *Staphylococci*, yeast, mold, proteolytic and lipolytic microorganisms. While, *Salmonella* species couldn't be isolated from any of the examined samples. Therefore, public awareness targeting the imported companies and good hygienic practices should be fulfilled during handling, processing, storage and distribution, in addition to the applied control by the respective authority for protecting the consumer safety. Finally, the study provides a useful information for marketing companies for foreign brands to understand their hygienic quality and government trade policies.

ACKNOWLEGEMENTS

First and before all, thanks god the most graceful and the most merciful. I would like to express my gratitude to the professors of Milk Hygiene and Control, Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Cairo University, Egypt for their valuable ideal guidance and constructive criticism.

NOVELTY STATEMENT

The present study delivered the laboratory evaluation of the imported milk powder, labneh and cheddar cheese from New Zealand, Ireland, Turkey, Poland, Netherlands (Holland), European Union and Switzerland dairy products and retailed in the Egyptian markets. Microbiological examination revealed higher contamination level of the imported milk powder in comparison to the examined labneh and cheddar cheese, with isolation of the pathogenic *E. coli*.

AUTHOR'S CONTRIBUTION

Esraa Yosry abdel Halim: Conceptualization, Methodology, Writing- Original draft preparation. Hamdy El-Essawy: Conceptualization, Visualization, Supervision. Abeer Abdel Nasser Awad: Conceptualization, Writing - Review & Editing, Visualization & supervision. Mona S. El-Kutry: Investigation, Visualization Lamiaa Ibrahim Ahmed: Conceptualization, Methodology, Investigation, Review and editing.

Conflict of interest

The authors have declared no conflict of interest.

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