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QUALITY ASSESSMENT OF SWEETENED CONDENSED AND EVAPORATED MILKS IN ALEXANDRIA GOVERNORATE

(With 4 Tables)

By

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تقييم جودة الألبان المكثفة المحلاة و المبخرة في محافظة الإسكندرية

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يعتبر اللبن المركز غذاء صحي يدخل في صناعات منتجات الألبان مثل الأيس كريم والحلويات وذلك لما يحتويه من عناصر غذائية هامة تجعله ذو قيمة عالية إلا أنه قد يتعرض للتلوث من مصادر مختلفة أثناء الإنتاج أو التداول مما يؤثر على جودته نتيجة تغيرات غير مرغوبة تجعله غير صالح للاستهلاك الآدمي. تم تجميع عدد ٤٠ علبة من اللبن المركز مقسمة إلى عينات من اللبن المكثف المحلى و اللبن المبخر(٢٠ علبة من كل نوع) جمعت من مناطق مختلفة من محافظة الإسكندرية وذلك لفحص جودة هذا المنتج. وقد تم فحص هذه العينات كيميائيا وميكروبيولوجياً ومقارنتها بالموصفات القياسية العالمية لتحديد سلامة وجودة هذه العينات من الناحية الصحية. وتبين أن معظم العينات كانت سليمة من الناحية الطبيعية والحسية. وكان متوسط نسبة الجوامد الكلية، الدهن، سكر السكروز، الماء للسكر في عينات اللبن المكثف المحلى هو ٣٠,٤ ± ٠,٣١ ، ٩,١٨ ± ٠,١١ ، ٤٣,٩٣ ± ٠,٥٤ ، ٦٢,٩٤ ± ٠,٤٣ % على التوالي وكان متوسط نسبة الجوامد الكلية، الدهن في عينات اللبن المبخرهو٢٣,١٧ ±١,٦٤، ٨,٥٤ ± ٠,١٢ % على التوالي. وكان متوسط العد الكلي البكتيري الهوائى واللاهوائى في عينات اللبن المكثف المحلى واللبن المبخر هو ٣,٠٥x١٠^{٢} ±١٠x٢,٣٣، ±١٠x١,٠٧ و١٠x٠,٨٨ ± ١٠x١,١ +١٠^{٢} x ٩,٤، ١٠ x ١,٣٣ ± ٠,٣٣ x ١٠ على التوالي. كان نسبة تواجد ميكروب الإنتيروكوكاي في عينات اللبن المكثف المحلى هو ٢٥ % بينما متوسط الفطريات المحبة للبرودة هو ٦,٤٤ x ١٠ + ٢,٧ x ١٠ بينما كان متوسط الفطريات في عينات اللبن المبخر هو ٠,٩٥ x١٠ ± ٠,٢٥ x١٠ . وكانت نسبة تواجد ميكروب الباسيلاس سيرس هو ٢٥ % بمتوسط قدره ٨,٧٥ x ١٠ ± ٠,٧ x١٠ ميكروبات الكولىفورم ، السالمونيلا ، الكوليستريديم بيرفرنجنز لم تعزل من العينات المفحوصة. وتم مناقشة الأهمية الصحية والإقتصادية للعترات المعزولة.

SUMMARY

Concentrated milk is extensively imported from different countries abroad. These products, with their greater concentration of milk solids, are useful in the manufacture of ice cream, candies, and a variety of other food items. Forty random samples of concentrated milk (20 each of sweetened condensed and evaporated milks) of different brands were collected from large supermarkets in Alexandria Governorate. All examined concentrated milk samples were subjected to the physical and organoleptic evaluation. The mean values of total solids, fat, sucrose contents and sugar/water ratio in the examined sweetened condensed milk samples were 30.4±0.31; 9.18±0.11; 43.93± 0.54 and 62.94±0.43, respectively. While, the mean values of total solids and fat content in examined evaporated milk samples were 23.17±1.64 and 8.54±0.12, respectively. The mean values of aerobic plate count, anaerobic plate count in the examined sweetened condensed milk and evaporated milk samples were $3.05x10^2$±1.07x10 and 2.33x10±0.88x10; $1.1x10^2$± 9.4x10 and 1.33x10± 0.33x10 cfu/g, respectively. *Enterococci* contaminated 25 % of the examined sweetened condensed milk samples with varying numbers. Osmophilic fungi were found in 25% of examined sweetened condensed milk samples with a mean value of 6.44x10±2.7x10. While, the mean value of total yeast and mould count in examined evaporated milk was 0.95x10±0.25x10 cfu/g. *Bacillus cereus* contaminated 20% of examined condensed milk samples with a mean value of 8.75x10±7.0x10. *Salmonellae*, Coliforms and *Clostridium perfringens* failed to be detected in the examined samples of concentrated milk. The public health, economic importance of the isolated species and suggested control measure were discussed.

Key words: *Milk, condensed milk, evaporated milk*

INTRODUCTION

Dairy products of reduced moisture content may be produced to achieve savings in transportation and merchandising costs related to the reduced volume and weight.These products, with their greater concentration of milk solids, are useful in the manufacture of ice cream, candies, and a variety of other food items (ADPI, 2000).

The keeping quality of sweetened condensed milk is largely the result of the increase in osmotic pressure (reduction in water activity) and the binding of water by the added sugar. The increased

concentration of milk solids brought about by the removal of water by evaporation also contributes to the increase in osmotic pressure, but this is relatively minor compared to the effect of added sugar. The use of sugar to extend the shelf life should not be considered a substitute for good quality raw milk, proper sanitation, and /or adequate processing and holding practices. The heat treatments employed in processing are insufficient to sterilize the product, so residual organisms are always present to cause problems if the product is not handled satisfactorily (Robinson, 2002).

Evaporated milk usually show no viable organisms when examined by customary procedures immediately after packaging, and microorganisms seldom develop even after prolonged holding at usual room temperatures, although defects do appear occasionally (Clark, 2000). Microbial defects can be divided into those organisms of high heat resistance that survive slightly inadequate heat treatment and those which gain entrance after heat treatment, and which are usually of low heat resistance.

The main source of contamination of condensed milk by these microorganisms may be from imperfectly cleaned machinery and incompletely sterilized tins (Garcia, 1959). A general risk due to post-processing contamination, of course, exist with non-sterile products, while sterilized concentrated milk is subjected to the same risks as all canned foods with respect to under processing and seam leakage (Varnam and Sutherland, 1994). Several outbreaks of acute gastrointestinal disturbance have been reported due to consumption of condensed milk (Cockburn and Vernon, 1956). Apergillus, Penicillium, Coliforms and spore formers may associate with defects in condensed milk, especially if the canned products are held for longer time (Robinson, 2002).

Concentrated milk is extensively imported from different countries abroad. It is exposed for sale in markets under various trade names; therefore, this work was planed to assess the quality of concentrated milk retailed in Alexandria Governorate.

MATERIALS and METHODS

1. Collection of samples

Forty random samples of concentrated milk (20 each of sweetened condensed and evaporated milks) of different brands were collected, in duration of 6 months, from large supermarkets in

Alexandria Governorate. Samples were still valid for consumption as shelf life is at least to be ½ -1 year from production time. Samples were transported to the laboratory with a minimum of delay and examined to assess their quality.

2. Physical examination

3. organoleptic examination.

4. Chemical examination:

4.1. Determination of fat content (IDF, 1987a).

4.2. Determination of total solids content (IDF, 1987b and 1988).

4.3. Determination of sugar /water ratio (Clark, 2000).

4.4. Determination of sucrose content (AOAC, 1990).

5. Preparation of samples for the microbiological evaluation

Ten- fold serial dilution was prepared as described by AOAC (1990).

6. Microbiological counts:

6.1. Aerobic plate count (APHA, 1992).

6.2. Anaerobic plate count (APHA, 1992).

6.3. Coliforms count (APHA, 1992).

6.4. Enterococci count (Efthymiou *et al,*. 1974).

6.5. Total Yeast and Mold count in evaporated milk (Bailey and Scott, 1998).

6.6. Osmophilic Yeast and Mold count in sweetened condensed milk (Bailey and Scott, 1998).

6.7. Isolation and identification of Salmonella species (Cox, 1988).

6.8. Bacillus cereus count (Holbrook and Anderson, 1980). Suspected colonies were picked up for further confirmation according to Kramer *et al.,* (1982).

6.9. Clostridium perfringens count (Angelotti *et al.,* 1962). Suspected colonies were picked up for further confirmation according to Mead *et al.* (1981).

RESULTS

The obtained results of chemical and microbiological examinations of both condensed and evaporated milk samples are recorded in Tables 1-4.

Table 1: Results of chemical analysis of the examined samples of concentrated milks.

Products	Sweetened condensed milk (full cream)			Evaporated milk		
	Mean ± SEM	MPL (APHA,1992)	Samples failed to comply standard	Mean ± SEM	MPL (FDA,1999)	Samples failed to comply standard
Total solids	30.4 ± 0.31	28	0	23.17 ± 1.64	23	0
Fat content	9.18 ± 0.11	8.0	0	8.54 ± 0.12	6.5	0
Sucrose %	43.93± 0.54	43	0	-	--	-
Sugar/water ratio	62.94± 0.43	60-66	0	-	-	-

MPL: maximum permissible limits

Table 2: Results of microbial counts of examined samples in sweetened condensed milk (N=20).

Counts	Positive samples					MPL/g (APHA 1992)	Samples exceed MPL	
	No.	%	Min.	Max.	Mean + SEM		No.	%
Aerobic plate	15	75	1.0x10	$6.0x10^3$	$3.05x10^2 \pm 1.07x10$	<500	5	25
Anaerobic plate	3	15	0.8x10	$3.0x10^2$	$1.1 \times 10^2 \pm 9.4x10$	-	-	-
Bacillus cereus	4	20	1.0x10	$3.0x10^2$	-	-	-	-
Enterococci	5	25	1.0x10	$4.5x10^2$	-	-	-	-
Osmophilic fungi	5	25	2.0x10	$1.4x10^2$	6.44x10± 2.7x10	<10	5	25

Table 3: Results of microbial counts of examined samples in evaporated milk (N=20).

Counts	Positive samples				
	No.	%	Min.	Max.	Mean + SEM
Aerobic plate	3	15	1x10	$4.0x10^2$	2.33x10 ± 0.88x10
Anaerobic plate	2	10	1x10	2.0x10	1.33x10 ± 0.33x10
Yeast and mould	2	10	0.7x10	1.2x10	0.95 x 10 ± 0.25 x 10

Table 4: Incidence of different microorganisms isolated from concentrated milk.

Isolates	Sweetened condensed milk		Evaporated milk	
	NO.	%	NO.	%
Enterococci			-	-
Ent. Faecalis	4	20	-	-
Ent. Faecium	5	25		
Moulds				
Alternaria alternaria	1	5	1	5
Apergillus flavus	2	10	1	5
Apergillus niger	4	20	-	-
Penicillium Spp.	4	20	1	5

DISCUSSION

1. Physical examination

All collected samples were physically inspected by naked eye for the presence of any abnormalities. None of the samples had deformities that render it unfit for human consumption.

2. Organoleptic examination

All examined concentrated milk samples conformed to the organoleptic requirements stated by (APHA, 1992) for color, the color should be milky white or milky yellow and have a luster. For taste and smell, it should have a milky aroma and a fine sweet taste for sweetened condensed milk. For texture, the consistency must be fine and smooth, with the texture even and the viscosity moderate.

2. Chemical examination:

Results given in Table 1 revealed that the mean values of total solids, fat, sucrose contents and sugar/water ratio in examined sweetened condensed milk samples were 30.4±0.31; 9.18±0.11; 43.93± 0.54 and 62.94±0.43, respectively. All of the examined sweetened condensed milk samples were conformed to the chemical standard stated by AHPA (1992) for total solids (28%), fat (8%), sucrose (43%) and sugar/water ratio (60-66%). As Sweetened condensed milk is preserved by addition of sugar, consequently its water activity is reduced to a point inhibitory to most microorganisms. Also, the increased milk solids content decreases the water activity. The sugar-in-water concentration of sweetened condensed milk is called the sugar/water ratio.

In addition, Table 1 showed that the mean values of total solids and fat content in the examined evaporated milk samples were 23.17±1.64 and 8.54±0.12, respectively. All evaporated milk samples were conformed to the chemical standards stated by FDA (1999) for total solids (23%) and fat (6.5%).

3. Microbiological examination:

3.1. Aerobic plate count:

Table 2 showed that the mean value of aerobic plate count in the examined sweetened condensed milk was $3.05x10^2$±1.07x10 cfu/g. According to the standard specified by APHA, (1992), the total bacterial count /g of sweetened condensed milk should not exceed 500/g, consequently 25% of examined samples do not comply with such standard, however, Sallam (1979) and Ahmed *et al.,* (1988), reported higher results. While, the mean value of aerobic plate count in the examined evaporated samples milk was 2.33x10±0.88x10 cfu/g (Table 3).

Many authors recommended the aerobic plate count as an index of hygienic measure, organoleptic quality, safety and utility of the product. It reflects the microbial content of raw materials and effectiveness of manufacture techniques and sanitary care of equipment and utensils (Adams and Moss, 2000).

3.2. Anaerobic plate count:

Presence of anaerobes in the examined samples of concentrated milk could be used as an index of fecal or soil contamination of such products, and it was shown that there was a definite correlation between the hygienic condition of production and the content of anaerobic spore-forming bacteria in these products (Robinson, 2002).

The mean values of anaerobic plate count in the examined sweetened condensed and evaporated milk samples were $1.1x10^2$± 9.4x10 and 1.33x10± 0.33x10 cfu/g, respectively (Table 2&3). Contamination may be due to a leaky can the non spore-forming types are the usually the cause of spoilage. Leaks in the hermetic seal of the container may be due to improper closure, subsequent corrosion or mechanical injury during subsequent handling; even a momentary leak may permit microbial entry.

3.4. Enterococci count

Table 2 revealed that 25 % of the examined sweetened condensed milk samples contaminated with *Enterococci* by varying numbers. Higher incidences were reported by Sallam (1979) and Ahmed *et al.* (1988). The presence of Enterococci may constitute a public health

hazard and may induce food poisoning because their ability to produce extracellular toxic metabolites (Banwart, 1998).

3.5. Osmophilic fungi count:

Osmophilic fungi were found in 25% of the examined sweetened condensed milk samples with a mean value of 6.44x10±2.7x10. Osmophilic fungi could be isolated from such product by Rao and Ranganathan (1970), Sallam (1979), Ahmed *et al.* (1988) and Korashy and Sabreen (2001). The mean value of total yeast and mould count in examined evaporated milk samples was 0.95x10±0.25x10 cfu/g (Table 3). The common isolated mould were Alernaria alternaria, Apergillus flavus, A. niger, and Penicillium. (Table 4). Ahmed *et al.* (1988) and Halawa (1997) reported similar isolates.

The main types of spoilage in sweetened condensed milk are osmophilic sucrose fermenting yeasts and molds. Growth of molds on these products increase pH towards neutrality permitting the growth of other bacteria that can be lead to rapid spoilage of the product (APHA, 1992).

The high counts of yeast and mold could be attributed to the contamination of sucrose; therefore, sucrose should be checked for these contamination before processing. Species of *Apergillus* and *Penicillium* had been implicated in the production of mold in the surface of sweetened condensed milk when sufficient air is available for their growth. This problem can be eliminated by filling cans to a level that eliminate air for growth, using practices that reduce the probability of yeast and mold contamination after processing.

Generally, condensed milks are favorable media for the growth of a wide range of environmental contaminants. Canned sweetened condensed milk with its high sugar content may swell occasionally owing to the growth of yeasts (Tudor and Board, 1993). If the can is under filled, however, the large headspace may allow enough oxygen for mold growth to occur on the product surface. Molds may contaminate the product between the pasteurizer and the can-closing machine through a defective seal or pinhole or the contamination can arise from filling equipment and non- sterile cans. Mold growth often occurs as buttons i.e. small areas of mycelial growth on the surface of the stored product. The molds most likely to be present are *Apergillus* and *Penicillium* (Milner, 1995).

Concerning, the public health significance and the pathogenesis of mycotoxins, it well known that in many cases, potential problems involve the possibility of cancer or delayed organs damage due to

repeated ingestion of sub acute levels. Certain food borne yeasts and molds may be hazardous because of their ability to elicit allergic reactions. Aflatoxin M_1 is highly toxic, mutagenic, teratogenic and carcinogenic compound that have been implicated as causative agent in human hepatic and extra hepatic carcinogens (Adams and Moss, 2000 and Li *et al.*, 2000).

3.6. Bacillus cereus count:

The summarized results in Table 2 proved that the incidence of *Bacillus cereus* in the examined condensed milk samples was 20% with a mean value of 8.75x10±7.0x10. The incidence of *Bacillus cereus* in condensed milk obtained in this study was lower than that recorded by Korashy and Sabreen (2001) and Abd El-Haleem (2004) who recorded that 28% of condensed milk was contaminated by *Bacillus cereus.* However, Ahmed *et al.*, (1988) could not detect *Bacillus cereus* in the examined condensed milk samples. The presence of high number of *Bacillus cereus* organisms in a variety of food has been found to associate with the production of either emetic or diarrhogenic, extracellular protein heat labile, toxins (Kawamura *et al.*, 2005). On the other hand, *Salmonellae*, Coliforms and *Clostridium perfringens* failed to be detected from the examined samples of concentrated milk as efficient heat treatment destroys Salmonellae and coliforms (Robinson, 2002).

Because of the heat processes and packaging used in manufacture of evaporated milks, the product is commercially sterile. That means the product is free of all microorganisms of public health significance and does not show microbial defects during its intended shelf life under normal conditions of handling, storage, and distribution. Whereas vegetative cells do not survive evaporated milk processing, and absolute sterility is obtained in most cans, small numbers of non-pathogenic spores occasionally may survive the heat treatment and, depending on the microorganisms and its previous growth and heat exposure, subsequently may germinate (Marth and Steele, 2001).

The consumer must be made aware of the perishability of evaporated milk once the can is opened. The heat treatment used to kill the organisms and provide keeping quality in the unopened can has no residual effect that will control the growth of subsequent contamination, and opening the can under kitchen conditions is almost lead to some contamination. Careful cleaning of the top of the can and immersion in boiling water for several minutes will kill most, but not necessarily all, of the organisms on the can surface. The initial microflora are those of

the raw milks from which the condensed milk has been made, besides the sugar used in such product may contain spore forming bacteria, yeasts and molds (Milner, 1995).

In general, sweetened condensed milk is not a sterile product, and the various methods of heat treatment used are not adequate to kill spore-forming bacteria, and further processing and handling usually contribute a variety of microorganisms, besides the sugar, levels employed permit some types to grow if other conditions are favorable. Enough oxygen may be present in the headspace of an incompletely filled or poorly sealed container, to permit the growth of organisms able to tolerate the high osmotic pressure of the product.

In conclusion, using high quality raw milk and fine clean sugar in condensed milk manufacture, good sanitation and hygiene during production, handling and storage of such product are important to prevent the condensed milk from spoilage and to protect the consumer from infection. In addition, a high standard of plant hygiene is needed to avoid post-processing contamination. However, the heat treatments used in production of condensed milk are insufficient to sterilize the product, so strict hygienic measures are still required. In addition, the viscous nature of this product needs to be taken into account for the cleaning procedures. Finally, employment of experienced staff is necessary at all times.

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