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QUALITY EVALUATION OF CONCENTRATED MILKS SOLD AT LOCAL MARKETS

(With 5 Tables)

By

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تقييم جودة الألبان المركزة المباعة فى الأسواق المحلية

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ان الالبان المركزة المحلاة وغير المحلاة موجودة فى الاسواق المحلية تحت مسميات تجارية مختلفة وكان هدفنا فى هذا البحث تقييم جودة هذه المنتجات من حيث الفحص الظاهرى والكيميائى والميكروبى وكذلك مقارنة النتائج بالمواصفات المصرية وذلك للتعرف على مدى جودة هذه المنتجات وأهميتها الغذائيه. لذلك تم فحص 60 عينة من كلا اللبن المكثف المحلى كامل الدسم واللبن المبخر الغير المحلى كامل الدسم وقد أسفر الفحص الظاهرى لكل العينات انها صالحه للأستخدام الآدمى وبالتحليل الكميائى وجد انه بالنسبة للبن المركز المحلى كامل الدسم متوسط نسبة المواد الصلبه الـ لـ بـ ن ية كانت 29.9±3.9 منها بروتين بمتوسط 8.2±1.1 ودهون بنسبة 8.5±1.1 ومواد صلبة غير دهنية بمتوسط 21.4±2.8 وحددت نسبة سكر اللبن (اللاكتوز) بمتوسط 9±0.2 وبذلك فان 100% من العينات المفحوصه كانت تتطابق مع المواصفات القياسية المصرية. اما بالتحليل الكميائى للبن المبخرالغيرمحلى كامل الدسم فقد كان المتوسط الكيميائى للمواد الصلبه اللبنية 28.92±1.2 منها بروتين بمتوسط 7.9±1 ودهون بنسبة 8.4±1.1 ومواد صلبة غير دهنية بمتوسط 20.37±2.6 وحددت نسبة سكر اللبن (اللاكتوز) بمتوسط 10.21±1.33 % وبذلك فان 100% من العينات المفحوصه كانت تتطابق مع المواصفات المصرية. اما بالنسبه للعدد الكلى البكتيرى الهوائى للبن المكثف المحلى واللبن المبخر فكانت 3.47×10^{3}±8.7×10^{2} و 8.46×10±3.2×10 على التوالى وبذلك فهى مطابقة للمواصفة المصرية بنسبه 25% للبن المركز و 90% للبن المبخر وكان متوسط العدد الكلى للبكتيريا المتحمله للحـرارة والمحبه للحرارة فى اللبن المكثف المحلـى والمبخـر هى 2×10±0.8×10 و 4.45×10±0.57×10 و 1.71×10±0.66×10 و 2×10±0.1×10 على التوالى وبذلك فهى مطابقه للمواصفة المصرية بنسبه 75% و80% للبن المركز و65% و 90% للبن المبخر على التوالى كما كان العدد الكلى للخمائر والفطريات هو 1.5×10±0.53×10 و 1.4×10±0.43×10 على التوالى وكان التطابق مع المواصفة المصرية ب نسبة 60% للبن المركز و65% للبن المبخر هذا ولم يتم عزل اي من ميكروبات الكوليفورم أو البكنريا اللاهوائية من جميع العينات وقد تم تصنيف المعزولات من الفطريات كما نوقشت الأهمية الصحية والأقتصادية لهذه الميكروبات وايضا تم تقييم المنتج واهميته للمستهلك.

SUMMARY

Concentrated milk is an important dairy product, because it can be utilized as a final product or as intermediate material. One hundred and twenty random samples of concentrated milk (60 each of full cream sweetened condensed and unsweetened evaporated milks) of different brands were collected from supermarkets in Alexandria Governorate for sensory, chemical and microbiological evaluations. The mean values of total milk solids, protein, solid not fat, fat and lactose contents in the examined full cream sweetened condensed milk samples were 29.9 ± 3.9, 8.2 ± 1.1, 21.4 ± 2.8, 8.5 ± 1.1 and 9.0 ± 0.2 , respectively. Meanwhile, the corresponding mean values of total milk solids, protein, solid not fat, fat and lactose contents in examined full cream unsweetened evaporated milk samples were 28.92 ± 3.7, 7.9 ± 1, 20.37 ± 2.6, 8.4 ± 1.1 and 10.21 ± 1.33. The mean values of aerobic plate count, thermoduric bacterial count, thermophilic bacterial count and total yeast and mould count in the examined full cream sweetened condensed milk samples were $3.47x10^3 \pm 8.7x10^2$; 2 x 10 ± 0.87 x 10; 4.45 x 10 ± 0.5 x 10 and 1.5 x 10 ± 0.53 x 10, respectively. Meanwhile in full cream unsweetened evaporated milk, the mean values of the concerning microorganisms were 8.46 x 10 ± 3.2 x 10; 1.71 x 10 ± 0.66 x 10; 2 x 10 ± 0.1 x 10 and 1.4 x 10 ± 0.43 x 10, respectively. Coliforms and anaerobic bacteria could not be detected in the examined samples of both concentrated milk types. The public health, economic importance of the isolated species and suggested control measures were discussed.

Key words: *Concentrated milk, sensory, chemical, microbiological, evaluation*

INTRODUCTION

In the early days in most countries, concentrated milk types were sold in such the same manner as liquid milk, because of their high milk solids, extended shelf life and considerable cost saving which obtained by transporting of the concentrates due to its reduced volume and weight (Hui, 1993).

Sweetened condensed milk is a nourishing, delicious, easily digestible and good source of energy. It is designed for use in the retail market in a variety of applications such as cooked and uncooked desserts, salad dressings and beverages as a topping for fruits or ice cream. Condensed milks can also be used undiluted in coffee and tea. Most condensed whole milk is used as an ingredient in chocolate/confectionery, or dairy industries (frozen dessert); while condensed skim milk is not

subsequently dried but it is used primarily within the dairy industry (ADPI, 2000).

Keeping quality of evaporated milk depends on the efficiency of sterilization of the final product and on the prevention of post-heat contamination while in condensed milks it depends primarily on concentration of added sucrose or other sugars and to some extent on the concentration of milk solids (NDPRC, 2009). The plasmolyzing action of the materials of solution prevents the growth of organisms (Robinson, 2002).

Microbiological evaluation of evaporated milk by customary procedures immediately after packaging will usually reveal no viable organisms, and microorganisms seldom develop even after prolonged holding at room temperature (Clark, 2000). In past years, much canned evaporated milk was held for 2-3 weeks in a warm room to detect spoilage before shipping; but, with improved technology and laboratory control, holding of the entire lot is seldom done (Robinson, 2002).

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 (Cockburan 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).

Both sweetened condensed and evaporated milks are extensively imported from different countries abroad. They are intended for sale in markets under various commercial names therefore, this work was planned to evaluate the quality of concentrated milk retailed in Alexandria Governorate.

MATERIALS and METHODS

1. Sampling:

One hundred and twenty random samples of full cream concentrated milk samples, comprises 60 samples each of unsweetened evaporated and sweetened condensed milk, were collected from different supermarkets in Alexandria Governorate. Samples were directly transferred, with a minimum of delay, to the laboratory of Animal Health Research Institute, Alexandria branch where they subjected for sensory, chemical and microbiological examinations.

2. Sensory evaluation *(Clark et al., 2009).*

3. Chemical evaluation: - (Milk content analyser, Lactostar, No. 3510)

4. Microbiological evaluation:-

4.1. Preparation of serial dilutions (APHA, 1992).

4.2. Aerobic plate count (APC) (APHA, 1992).

4.3. Thermoduric count (APHA, 1992).

4.4. Thermophilic count (APHA, 1992).

4.5. Coliforms count (MPN**)** (AOAC, 1994*).*

4.6. Total Yeasts and Moulds Count *(Bailey* and *Scott, 1998).*

4.7. Identification of moulds:- Raper and Fennel (1965) and Samson *et al. (1995)* for genus Aspergillus, Samson *et al.* (1995) for genus Penicillium, while other genera were identified according to Zycha *et al.* (1969); Barnnett and Hunter (1972) and Samson *et al.* (1995).

4.8. Detection of Anaerobic Spore formers by using Stormy Fermentation test according to (Cruickshank *et al.*, 1975*).*

RESULTS

Table 1: Statistical analytical results of Sensory evaluation of full cream sweetened condensed and full cream unsweetened evaporated milk samples against standard requirements (n = 60 for each) (Clark, 2000):

Criteria	Sweetened condensed milk samples not comply with standard requirements		Unsweetened evaporated milk samples not comply with standard requirements	
	No. (Characterization of defects)	%	No. (Characterization of defects)	%
Appearance of the container	8 (Rust and bad cans)	13	6 (Rust and bad cans)	10
Color and Luster	10 (Dark golden with luster)	17	0	0
Taste and smell	10 (Too sweet unpleasant taste)	17	0	0
Texture, Viscosity and Sediment	10 (more viscous with no sediment)	17	0	0
Feathering in coffee	-	-	3 (Make oil drops on coffee surface)	5%

Table 2: Statistical analytical results of Chemical composition of full cream sweetened condensed and unsweetened evaporated milk samples against Egyptian Standards (ES, part 1and 2, 2005) (n = 60 for each)

Criteria	Sweetened condensed milk			Unsweetened evaporated milk		
	Min - Max	Mean ± SEM	ES	Min - Max	Mean ± SEM	ES
TMS %	28.59 – 31.25	29.9 ± 3.9	28	28.52 – 29.14	28.92 ± 1.2	25
Protein %	7.63 – 8.8	8.2 ±1.1		7.60 – 8.17	7.9 ± 1	
SNF %	20.36 – 22.46	21.4 ± 2.8	20	20.25 – 20.52	20.37 ± 2.6	17
Fat %	8.23 – 8.79	8.5 ± 1.1	8	8.19 – 8.62	8.4 ± 1.1	7.5
Lactose %	8.43 – 9.44	9.0 ± 0.2		8.43 – 11.98	10.21±1.33	

TMS= Total Milk Solids, SNF= Solid Not Fat, Min = Minimum, Max = Maximum, SEM = Standard Error of Mean, ES. = Egyptian Standards.

Table 3: Microbiological evaluation of full cream sweetened condensed milk samples compared with Egyptian Standards (ES, part 2,2005) (n =60).

Criteria	Positive samples		Min - Max	Mean ± SEM	ES	Samples not complied with ES	
	No.	%				No.	%
Aerobic Plate Count	49	81.7	5 x 10 – 1.1 x 10^4	3.47 x10^3 ± 8.7x10^2	≤100	45	75
Coliforms count (MPN)	0	0	0 - 0	0	0	0	0
Thermoduric bacterial count	15	25	1 x 10 - 3 x 10	2 x 10 ± 0.87 x 10	0	15	25
Thermophilic bacterial count	12	20	2 x 10 - 6 x 10	4.45 x 10 ± 0.57x10	0	12	20
Total Yeast and Mould count	24	40	1 x 10 - 3 x 10	1.5 x 10 ± 0.53 x 10	0	24	40
Detection of Anaerobic bacteria (SFT)	0	0	0 - 0	0	0	0	0

Table 4: Microbiological criteria/ ml of full cream unsweetened evaporated milk samples compared with Egyptian Standards (ES, part 1, 2005) (n = 60).

Criteria	Positive samples		Min - Max	Mean ± SEM	ES	Samples not complied with ES	
	No.	%				No.	%
Aerobic Plate count	24	40	$1 \times 10 - 1.73 \times 10^3$	$8.46 \times 10 \pm 3.2 \times 10$	≤100	6	10
Coliforms count (MPN)	0	0	0 – 0	0	0	0	0
Thermoduric bacterial count	21	35	1 x 10 – 3 x 10	1.71 x 10 ± 0.66 x 10	0	21	35
Thermophilic bacterial count	6	10	1 x 10 – 2.4 x 10	2 x 10 ± 0.1 x 10	0	6	10
Total Yeast and Mould count	21	35	1.16 x 10 – 2 x 10	1.4 x 10 ± 0.43 x 10	0	21	35
Detection of Anaerobic bacteria (SFT)	0	0	0 - 0	0	0	0	0

Table 5: Frequency distribution of the identified mould species isolated from the examined full cream sweetened condensed and unsweetened evaporated milk samples (n = 60 for each).

Isolated mould species	Sweetened condensed milk		Unsweetened evaporated milk	
	Frequency	%	Frequency	%
Alternaria alternaria	3	5.00	2	3.30
Aspergillus flavus	5	8.33	4	6.67
Aspergillus fumigates	3	5.00	2	3.30
Aspergillus niger	4	6.67	6	10.00
Aspergillus terreus	5	8.33	4	6.67
Penicillium spp.	4	6.67	3	5.00
Total	24	40	21	34.94

DISCUSSION

1. Sensory evaluation

All samples were examined before opened (closed cans examination), and after opening for surface appearance, luster, texture, color, viscosity, sediment, flavor and the product reaction to hot drinks. They all were normal with no abnormalities, except some uniformity, rusts, and impropriate appearance of some cans (Table, 1). The labeling requirements were carried out according to the regulations in FDA (2006). None of the samples has deformities that render it unfit for human consumption.

The body characteristics of concentrated milks have been markedly improved through the use of stabilizers that prevent physical separation during storage and help the product to be smooth and creamy throughout typical distribution cycles (Garcia, 1959).

Data recorded in Table (1) showed that ten samples of sweetened condensed milk were not complying with these requirements (color, luster, taste, smell, texture or viscosity), they all were from one brand and it was somewhat different from the other tested brands just in sensory parameters neither chemical nor microbiological.

2. Chemical examination:

Generally the total solids content of a product is a key parameter in food industry. It can be part of the determination of the final product composition. The water content of a product is often regulated by legislation and might strongly influence the product's stability. During food processing, the total solids content often affects final product quality (Davis, 1970). All evaporated milks and most sweetened condensed, milk products are manufactured using raw milk grade (A) (USPHS, 1997).

Results registered in Table (2) revealed that all samples of full cream sweetened condensed milk were complied with the Egyptian Standards, part2 (2005) in both total milk solids which must not be less than 28% and fat requirement not less than 8%. As well all full cream unsweetened evaporated milk samples were complied with the Egyptian Standards, part1 (2005) in both total milk solids and fat % which are not less than 25 and 7.5%, respectively.

As full cream sweetened condensed milk is preserved by addition of sugar, consequently its water activity is reduced to a point inhibit the growth of most microorganisms. Also, the increased milk solids content decreases the water activity.

3. Microbiological evaluation of concentrated milk samples:-

Dairy products have generally been considered an excellent source of high-quality protein, calcium, potassium, phosphorus, magnesium, zinc, and the B-vitamins riboflavin, niacin, vitamin B-6, and vitamin B-12 Buttriss (1997). Not only but they are also an excellent media for most microbial organisms.

Table (3) showed that the mean value of aerobic plate count in the examined sweetened condensed milk was $3.47 \times 10^3 \pm 8.7 \times 10^2$ cfu/g. According to the standard specified by APHA (1992), the total bacterial count /g of sweetened condensed milk should not exceed 500/g, so 25% of examined samples do not comply with such standard, while 75% of the examined samples don't comply with the ES, part2 (2005) which require less than 100 cell/g of milk. However, Sallam (1979) and *Ahmed et al.* (1988), reported higher results. In Table (4) the mean value of aerobic plate count in the examined evaporated milk samples was 8.46x10±3.2x10 cfu/g, only 10% of the examined samples were not complied with the ES.part1 (2005).

However, Arora (1987) and Robinson (1990) recorded different ranges during their works on the same product. They found that the viable counts ranged between few hundred to 10^4 cfu/g, while the mean of tested samples of sweetened condensed milk was 8.46x10±3.2x10 cfu/g with a range between 50:11.000 cfu/g.

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).

The main source of contamination of condensed milk by microorganisms may be from imperfectly cleaned machinery and incompletely sterilized tins (Garcia, 1959).

In Tables (3) thermoduric bacterial count and thermophilic bacterial count were found in a mean of 2 x 10 ± 0.87 x 10 and 4.45 x 10 ± 0.57 x 10 cfu/g for full cream sweetened condensed milk samples which complied with the ES (part 2, 2005) in percentages 75% and 80% consequently. Meanwhile in Table (4) they were 1.71 x 10 ± 0.66 x 10 and 1.5 x 10 ± 0.19x10 cfu/g of full cream unsweetened evaporated milk samples were complied with ES (part 1, 2005) in percentages of 65 and 90% respectively.

Spore-forming bacteria present in raw milk are destroyed by exposure to time and temperature combinations currently used for milk pasteurization, but full cream 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 variety of microorganisms. Here comes the rule of sugar concentration which reached up to 45% in preserving sweetened condensed milk by reducing water activity to a point inhibit most microorganisms.

Full cream unsweetened evaporated milk is commercially sterile, and must be free from all microorganisms of public health significance and must not show microbial defects during its intended shelf life under normal conditions of handling, storage and distribution (Robinson, 2002; NDPRC, 2009).

As in its manufacture milk is quickly heated in one of two ways. The High Temperature Short Time method (HTST) subjects milk to temperature of 161 °F (71.6°C) for 15 seconds. The Ultra High Temperature (UHT) method heats the milk to 280°F (138°C) for two seconds and both methods increase the milk's stability, decrease the chance of coagulation during storage, and decrease the bacterial level (Curran and Evans, 1945).

But high viable count often indicates contamination of raw material, unsatisfactory sanitation or unsuitable time and temperature conditions during storage and/or production specially during cooling and filling process in sweetened condensed milk or the microorganisms may also enter to the unsweetened evaporated milk cans through defective seems during cooling or during passage along the wet and contaminated tracks ways Mossel (1983).

Also, some spores can survive pasteurization and affect the quality of fluid milk and other processed dairy products.

Neither Coliforms nor anaerobic bacteria could be detected in all examined samples. These results were complied with ES.part 1 and 2 (2005) as it requires negative *Coliforms and negative anaerobes;* also Ahmed *et al.* (1988) couldn't detect them. Robinson (2002) stated that Coliforms, may die off with holding, but yeast and moulds may proliferate.

Total Yeast and Mould counts were shown in Table (3) for full cream sweetened condensed and in Table (4) for full cream unsweetened evaporated samples, with means of $1.5 \times 10 \pm 0.53 \times 10$ and $1.4 \times 10 \pm 0.43 \times 10$ cfu/g, respectively. They were complied with the ES (part 1 and 2, 2005) with percentages of 60 and 65%, respectively.

Some moulds are capable of producing toxic metabolites known as mycotoxins, such as aflatoxins which are known as carcinogens (Massey *et al.*, 1995; Markaki and Melissari, 1997).

Generally, concentrated milks are considered as favorable media for the growth of a wide range of environmental contaminants. Canned full

cream sweetened condensed milk with its high sugar content may swell occasionally owing to the growth of yeasts (Tudor and Board, 1993). Moulds 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. Moreover, moulds may grow over an extremely wide range of temperature, therefore, they can be present on practically all food at almost any temperature under which foods are hold. The sugar is normally an unimportant source of microorganisms, but under unfavorable conditions, it may be contaminated with mold spores, osmophilic yeasts, or bacteria that will produce acid and gas.

Moulds most likely to be present are Aspergillus and Penicillium (Milner, 1995). Classification was done for the mould isolates. The results were in Table (5), revealed the presence of Alternaria alternaria, Aspergillus flavus, Aspergillus fumigates, Aspergillus niger, Aspergillus terreus, Penicillium spp. in full cream sweetened condensed milk samples in percentages of 5, 8.33, 5, 6.67, 8.33 and 6.67%, respectively. While in full cream unsweetened evaporated milk samples they were found in percentages of 3.3, 6.67, 3.3, 10, 6.67 and 5%, respectively. Yeasts and moulds are undesirable organisms in most dairy products because they affect flavor and odor Ali *et al.* (2006).

Equally important is the fact that milk is an excellent source of nutrients for humans, and yet in a different context the same nutrients provide most suitable media for microbial growth and metabolism. Many important pathogens like Salmonella spp. and Listeria monocytogenes will grow in liquid milk or high-moisture milk products; and even if these vegetative forms can be eliminated by pasteurization, the spore-formers may cause problems. It is not surprising, therefore, that the quality evaluation of milk and milks products remains a priority interest for everyone associated with the dairy industry (Foster *et al.*, 1983).

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