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REGULAR ARTICLE

Nutritional value and sanitary evaluation of raw Camel's milk

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Abstract

The present study was carried out to investigate the nutritional value and hygienic status of fresh camel's milk collected for a period of 12 weeks (on weekly basis). The milk samples were divided into two portions under sterile conditions. The 1st portion was examined for the gross composition (total solids, solids non fat, moisture, fat, protein, lactose and chloride). The 2nd portion was examined for the sanitary condition through monitoring sensory evaluation, acid value and determination of fecal contamination. Wide variation was observed in the chemical analysis of the different milk constituent. The global mean values of total solids, solids non fat, fat, protein, lactose, chloride, and moisture were 10.8 ± 0.3, 7.9 ± 0.2, 2.84 ± 0.2, 4.02 ± 0.1, 3.8 ± 0.1, 0.15 ± 0.003, and 89.5 ± 0.4% respectively. The results of sensory evaluation indicated that the color was the most accepted attribute has the best score 7.9 and graded very good, then odor scored 6.8 and graded as slight good. The taste, over all acceptability (OAA) and flavor had fair grades and scored 5.4, 5.4 and 5.3 respectively. The average content of titratable acidity was 0.21 ± 0.01%. The bacteriological analysis revealed that coliforms, fecal coliforms and E. coli were detected among the study period with incidence varied from 28.6 to 100% for coliforms and 28.6 to71.4% for both fecal coliform and *E. coli*. Also, this study revealed presence of a relation between frequency distribution of coliforms and sensory scores.

Key words: Camel's milk, Nutritional value, Sanitary, Sensory evaluation, Growth composition

Introduction

In Egypt the majority of people consume cow's milk regularly than camel milk, due to the fact that cows and buffalos give much more milk and require less maintenance and labor. Unfortunately, people are unaware about the nutritional facts and healthy benefits of camel's milk. Camel's milk composition is different from that of ruminants (Al-Haj and Al-Kanhal, 2010) as is their physiology (Shabo et al., 2005). The value of camel's milk is due to its high concentration of volatile acid especially linoleic acid and poly unsaturated fatty acid which are essential for human nutrition, rather it is rich in mono-unsaturated fatty acid (Gast et al., 1969; Karry et al., 2005; Konuspayeva et al., 2008). Camel's milk is regarded to be abundant source of protein for people living in arid lands of the world. This protein is rich in protective component include lysozyme, lactoferrin, Lactoperoxidase (LP) and peptidolgycan recognition protein (PGRP) which only detected in camel's milk (Singh et al., 2006), IGA and IGg immunoglobulins that are compatible with human ones and provide effective defense against several viral and bacterial pathogens (Khitam, 2003).The fact that camel's milk is low in different β–caseins (Beg et al., 1986) and without β- lactoglobulin (Merin et al., 2001) the 2 powerful allergens in cow's milk makes it attractive for those suffering from milk allergies (Mankinen and Palosuo, 1992; Shabo et al., 2005). Camel's milk is a rich source of chloride (Khaskheli et al., 2005) and its lactose is easily metabolized by persons suffering from lactose intolerance (Hanna, 2001). The vitamin C levels are more than three times that of cow milk and one-and-a-half that of human milk (Konuspayeva et al., 2011). Camel's milk is also having low sugar, low protein and high minerals (sodium, potassium, iron, copper, zinc, selenium and magnesium) (Konuspayeva et al., 2008). Camel's milk consumption may also be helpful in reducing the nutritional deficiencies and morbidities in adult community (Agrawal et al., 2005; Singh et al., 2009).

In Egypt camel's milk is produced in traditional way by hand milking, handled and transported under low hygienic measures. In view of its health benefits, there is a fast growing demand for raw

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camel's milk around the world (Faye and Bonnet, 2012) and further it is introduced recently as a new functional food in the European market. Therefore, there is a high necessity to find out about the present hygienic situation and nutritional value of raw camel's milk in Egypt.

The objective of this work was to study the nutritional value and sanitary condition of raw camel's milk.

Materials and Methods

Animals

It is extremely difficult to study a large number of camels on a regular basis taking into account the distance between the study area and the laboratory, lack of sufficient number of camels at one place and continues movement of herds. Therefore, this study was conducted on seven lactating dromedary she-camels (*Camelus dromedaries*) from a private camel herds belonging to Ebel El-Kher farms in Marsa Matroh, Egypt reared under satisfactory conditions and grazing on natural grass that grow in the desert

Samples collection

Seven fresh raw camel's milk samples (250 ml each) were collected individually weekly for 12 weeks. The samples were kept in ice box during transportation to the laboratory where they examined as soon as possible with a minimum of delay. Every individual sample thoroughly stirred before the analysis to obtain representative result for chemical and microbiological parameters.

Chemical analysis of camel's milk

Total solids (T.S. %)

A total solid was carried according to AOAC (1990).

Ten ml of camel's milk sample were placed in a previously weighed flat bottom porcelain dish (w), and then placed on a steam bath for 15 min, followed by heating in hot air oven at 100°C for 3 h. Heated samples were placed in a dissector for cooling then weighing (w\). Reading was taken at constant weight. T.S. % was calculated according to the following equation:

$$\text{T.S. \%} = \frac{\text{(Weigh of dish+ milk) - weigh of dish}}{\text{Weigh of sample}} \times 10$$

Determination of moisture %

It was calculated by subtracting T.S. % from 100.

Determination of fat % (APHA, 1985)

Gerber method was used to determine fat %. Briefly, 10 ml of concentrated sulphuric acid were placed into a clean and dry milk butyrometer, 11 ml of camel's milk sample were added followed by adding 1 ml of amyl alcohol into the butyrometer. The rubber stopper was firmly inserted and the butyrometer was shaken longitudinally very carefully and inverted several times until the curd is digested. The butyrometer was then placed in centrifuge and spun at 1500 rpm for 4 min. After which the fat content was read on the butyrometer scale at the lower part of meniscus.

Determination of solids non fat % (S.N.F. %)

S.N.F.% was calculated by subtracting the fat% from T.S.% and calculated according to the following equation:

S.N.F. %= T.S. % - fat%

Determination of protein %

Total Protein % was determined by formal titration method modified by Mumm (1970). Twenty-five ml of milk sample was added into a beaker. Then, 1 ml potassium oxalate solution (28%) and 0.25 ml phenolphthalein (2%) was added into the milk. After mixing, the solution was titrated against NaOH (N/7) until faint pink color appeared, and then 5 ml of neutralized formalin solution (40%) was added to the beaker in which the faint pink color disappeared. A second titration against NaOH (N/7) was preformed until the faint pink color appears again and the second reading was recorded as protein%.

Lactose % (Harvey and Hill, 1967)

Lactose % was estimated by quantitative Benedict method. In a cylinder (100 ml capacity), 10 ml milk sample, 40 ml distilled water, 10 ml of sulphuric acid 2/3N, 5 ml of sodium tungestate 10% were added. The mixture was brought up to 100 ml by addition of 35 ml distilled water. The cylinder was left to stand for 10-15 min to allow the formation of precipitate. The solution was then filtered through filter paper and a clear filtrate was then transferred to burette. 25 ml of standard Benedict solution, 5 g anhydrous sodium carbonate and 50 ml distilled water were added in a porcelain dish. The mixture was boiled and titration against the filtrate was carried out during boiling until disappearance of blue color and appearance of white precipitate. The reading was recorded and multiplied by factor 0.067 (Each 0.067 g lactose reduces 25 ml Benedict).

Lactose % = 67/R

Chloride % (Ling, 1963)

10 ml milk sample, 5 ml nitric acid 25% (freshly prepared), 5 ml silver nitrate N/10, 1 ml saturated iron alum solution (indicator). The

solution was mixed thoroughly by glass rod and titrated against ammonium thiocyanate N/10 until brownish color (end point) was obtained and persisted for 1-2 min.

Chloride% = (5 - R) x 0.003546 × 10

1 ml silver nitrate N/10 = 1 ml ammonium thiocyanate

1 ml silver nitrate N/10 = 0.003546 g chloride

R = amount of thiocyanate N/10

5 = amount of silver nitrate N/10

5 - R = amount of silver nitrate N/10 combined with chloride

Sanitary evaluation of camel's milk

2.2.1. Sensory evaluation: All camel's milk samples were sensory evaluated by untrained panelists. using a 9-points hedonic scoring scales (9 = excellent, 8 = very good, 7 = good, 6 = slightly good, 5 = fair, 4 = slightly bad, 3 = bad, 2 = very bad, 1 = extremely bad) (Abdel Rahman et al., 2009). The samples were evaluated for color, smell, taste, flavor and overall acceptability (OAA). Also the panelists were asked to list any defects in the samples. All samples were subjected to clot on boiling test before testing its flavor and taste.

Determination of acidity value (Pearson, 1972)

Ten ml of well mixed camel's milk sample were placed into a clean dry beaker then 1 ml phenolphthalein 0.5% was added and titrated against NaOH N/10 until faint pink color appeared and persisted for at least 5 sec (end point) and the reading was recorded.

Lactic acid % = R/10.

Examination of camel's milk for fecal contamination: according to AOAC (1975)

Preparation of milk samples: Camel's milk samples were stirred thoroughly several times and then 10 ml was added to 90 ml of sterile peptone water (1/10 dilution), in which decimal serial dilutions were prepared according to APHA (1992).

Coliform count, fecal coliform count and E.coli count were determined using three tubes most probable number (MPN) method.

Coliforms count (MPN/ml)

Presumptive test: 1 ml of the previous prepared 1:10, 1:100 and 1:1000 dilutions was inoculated into 3 replicate tubes of lauryl sulphate tryptose (LST) broth supplied with inverted Durham's tubes. The inoculated tubes were incubated at 35°C and scored for gas formation at 24 and 48 hr.

Confirmatory test: All positive LST tubes were subculture into brilliant green lactose bile (BGLB) broth with inverted Durham's tube by means of 3 mm loop and were incubated at 35°C for 48±2 hr. the most probable number for total coliform bacteria per ml was computed by scoring the number of gas positive BGLB tubes at each dilution and calculated from MPN table.

Fecal coliforms count (MPN/ml): Using a 3 mm loop, samples from gassing BGLB tubes were transferred to EC broth tubes with inverted Durham's tubes and incubated at 45.5 °C in covered water bath for 48±2 hr.

***E. coli* count (MPN/ml)**

Gas positive EC broth tubes were streaked to Levine's eosin methylene blue (LEMB) agar plates and incubated at 35°C for 24±2 hr. typical nucleated dark center colonies with metallic sheen were considered to be E. coli positive and were selected for confirmation.

Data analysis: were expressed as mean ± standard error using SAS program (SAS, 1997).

Results and Discussion

Chemical analysis of camel's milk

Compositional analysis of fresh camel's milk was carried out for a period of twelve weeks (on weekly basis). Mean values for total solid contents of camel's milk varied from 9.7±0.3 to 12.5±0.7% with grand mean of 10.8±0.3% (Table 1). These results were comparable to Faye et al. (2008) and Farah (1993) while, they were lower than those reported by Moustafa et al. (2000); El Shaer and El Ganzoury (2008); and higher than what reported by Omer and El-Tinay (2009); Shuiep et al. (2008).

The moisture content mean values which varied from 87.5±0.8 to 91.6±0.6% with grand mean of 89.5±0.4% is in agreement with results of Omer and El-Tinay (2009) and Meiloud et al. (2011).

The grand mean of fat (in %) in camel's milk was 2.8±0.2 and ranged from 2±0.1 to 3.4±0.3% (Table 1). Fat content obtained in this study agreed with the value reported by Shuiep et al. (2008); Haddadin et al. (2008); Meiloud et al. (2011) while, Attia et al. (2001); Omer and El-Tinay (2009) reported lower values. Our results were lower than those reported by Al-Haj and Al-Kanhal (2010) and Konuspayeva et al. (2009). The grand mean value of S.N.F. was 7.9±0.2% and ranged from 7.1±0.6 and 9.5±0.8%. This result was similar to those recorded by Guliye et al. (2000) and Mal et al. (2006, 2007) and lower than those recorded by Iqbal et al. (2001) and El Zubeir and Ibrahium (2009). Camel's milk is considered to be abundant source of protein for people living in arid lands of the world. Our results showed that the grand mean value of protein was found to be 4.02±0.1% and

ranging from 3±0.3 to 4.5±0.2% (table 1). Protein content recorded in this study was agreed with the value reported by Faye et al. (2008) and Konuspayeva et al. (2010) while it was higher than that reported by Guliye et al. (2000); Moustafa et al. (2000); Iqbal et al. (2001); El Shaer and El Ganzoury (2008) and El-Zubier and Ibrahim (2009). Lactose is the major carbohydrate in the milk. The average lactose content was 3.8±0.1% and varied between 3.3±0.2 to 4.7±0.3%. These results were comparable to Haddadin et al (2008); Bakheit et al., (2008) and were lower than that recorded by Guliye et al (2000). The chloride content of camel's milk as shown in Table 1 varied from 0.14±0.008 and 0.16±0.003% with grand mean of 0.15±0.003%. These results were in the same line with Moustafa et al. (2000), while Khaskheli et al. (2005) recorded a higher result.

In general, the present study showed wide variations in the gross composition of camel's milk. These variations could be due to several factors including analytical measurement procedures, water availability, stage of lactation, age, breeds and number of calving, camel's diet and climate. Our study was done in the period from June to September, i.e. at summer time. Yet, camel having a seasonal reproductive cycle, the summer time is corresponding with the lactation peak when fat and protein in milk are at their lower values (Musaad et al., 2013).

Sanitary evaluation of camel's milk

Sensory evaluation

Good quality milk should have a pleasant sweet and clean flavor without distinct aftertaste

Camel's milk is generally opaque white (Yagil and Etzion, 1980; Desai et al., 1982), with normal odor and has faint sweet taste, a sweet but sharp (Ohri and Joshi, 1961), sometimes it is salty in taste (Rao et al., 1970; Desai et al., 1982). Due to practical reasons it was extremely difficult to recruit more people available to share in the sensory test on a regular basis for consecutive 12 weeks. Therefore, the sensory analysis of the examined camel's milk samples was performed by four untrained panelist compromising staff member and master student in the food hygiene department, faculty of veterinary medicine, Assuit University, Egypt. They were informed and trained to understand the used words such as flavor, OAA and sensory scores. Among all sensory attributes color had the best score during the twelve weeks with grand mean score 7.9 and were graded very good (Table 2). This may be attributed to the low content of carotene (Wernery, 2006); also camel's milk fat completely homogenized giving the milk a smooth white appearance (Abu-lehia, 1998). Odor had grand mean score 6.8 and were graded slight good, both taste and over all acceptability (OAA) had the same grand mean score 5.4 and were graded fair. The flavor had the lowest grand mean score 5.3 and was graded fair.

Acid value

Measuring the acidity is an important test used to determined milk quality (AOAC, 1990). The grand mean value of acidity was 0.21±0.01% and varied from 0.16±0.01 to 0.27±0.03% for a period of twelve weeks (Table 1). This result was in agreement with those recorded by El-Shaer and El-Ganzoury (2008); El-Zubier and Ibrahium (2009). Titratable acidity in the present study was higher than those recorded in other studies. This might be due to the relatively high temperature of milk after collection (Yagil and Etzion, 1980).

Fecal contamination of camel's milk

It is worth to mention that there are no microbiological standards specified to camel's milk. Therefore, the microbiological limit value for cow's milk is used to assess the quality of camel's milk (El-Ziney and AL-Turki, 2007). In this study, the microbiological results of camel's milk samples were compared with parameters laid down by European Union (EU) standards commission (Anonymous, 1992).

Most of examined samples were positive for total coliforms. The highest prevalence were found between the 3rd to 8th weeks (100%) for total coliforms, 2nd and 11th weeks (71.4%) for fecal coliforms and in the 11th week (71.4%) for *E.coli.* Table 4 shows the microbial distribution in the camel's milk among the twelve weeks. The highest frequency distribution (71.4%) for total coliforms was $<10^2$ in the 7th week, $< 10^3$ in the 3rd week and $<10^4$ in the 5th and 10th weeks. While the highest frequency for fecal coliforms and *E. coli* (71.4%) was < 10 in the 11th week. The existence of coliforms bacteria may not necessary to indicate direct fecal contamination of milk but precisely as an indicator for poor sanitary practices during milking and further handling processes. More over the presence of fecal coliforms i.e. *E. coli* implies the risk of fecal contamination and possibility of enteric pathogens existence.

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Table 1. Chemical composition of camel's milk (n=7) representing 12 consecutive weeks.

W	T.S.±S.E.	S.N.F±SE	Moisture±SE	Chloride±SE	Fat±SE	Protein±SE	Lactose±SE	T.A.
1	9.7±0.3	7.3±0.3	90.3±0.3	0.14±0.008	2.4±0.08	4.5±0.2	3.7±0.3	0.27±0.03
2	12.5±0.7	9.5±0.8	87.5±0.8	0.15±0.003	3±0.3	4.1±0.2	4.7±0.3	0.18±0.01
3	11.2±0.2	7.9±0.2	91.6±0.6	0.16±0.002	3.3±0.2	4.5±0.2	4.5±0.2	0.17±0.01
4	10.7±0.6	7.8±0.6	89.3±0.6	0.15±0.003	3±0.2	3±0.3	3.9±0.1	0.16±0.01
5	11.01±0.7	8.2±0.6	89±0.7	0.16±0.002	2.8±0.2	3.8±0.1	3.8±0.02	0.2±0.01
6	10.1±0.4	7.5±0.5	89.9±0.4	0.15±0.003	2.6±0.2	4.5±0.2	3.7±0.07	0.2±0.03
7	9.7±0.6	7.1±0.6	90.3±0.6	0.15±0.003	2.5±0.1	3.4±0.3	3.5±0.03	0.2±0.03
8	11.2±0.4	8.7±0.6	88.8±0.4	0.16±0.001	2.5±0.3	4.5±0.2	3.6±0.07	0.21±0.01
9	9.7±0.5	7.7±0.6	90.3±0.5	0.16±0.002	2±0.1	3.7±0.2	3.8±0.2	0.19±0.02
10	11.4±0.4	8.08±0.2	88.6±0.4	0.16±0.002	3.4±0.3	4.1±0.3	3.3±0.2	0.27±0.01
11	10.7±0.3	7.5±0.2	89.3±0.3	0.16±0.002	3.2±0.2	4.1±0.2	3.4±0.2	0.22±0.02
12	11.1±0.4	7.7±0.3	88.8±0.4	0.16±0.002	3.4±0.2	4.1±0.1	3.5±0.07	0.19±0.01
GM	10.8±0.3	7.9±0.2	89.5±0.4	0.15±0.003	2.8±0.2	4.02±0.1	3.8±0.1	0.21±0.01

T.S = total solids, S.N.F = solids non fat, T.A. = Titratable acidity

Table 2. Sensory evaluation scores* of camel's milk (n=7) representing 12 consecutive weeks.

W	Color		Taste		Flavor		Odor		OAA	
	Score	Grade	Score	Grade	Score	Grade	Score	Grade	Score	Grade
1	6.9±0.5	Good	4.7±0.5	Slight bad	5.4±0.4	Fair	6.4± 0.5	Slight good	5.2±0.3	Fair
2	8	Very good	5.3±0.2	Fair	5±0.3	Fair	6.4±0.3	Slight good	5.3±0.2	Fair
3	8	Very good	4.9±0.3	Slight bad	4.6±0.2	Slight bad	6.4±0.2	Slight good	4.7±0.2	Slight bad
4	8	Very good	6.1±0.3	Slight good	5.7±0.2	Fair	7.3±0.2	Good	6.1±0.3	Fair
5	8	Very good	5.3±0.2	Fair	4.7±0.3	Slight bad	6.9±0.2	Slight good	5.1±0.2	Fair
6	8	Very good	5.4±0.2	Fair	5.4±0.2	Fair	6.4±0.3	Slight good	5.4±0.2	Fair
7	8	Very good	5.6±0.2	Fair	5.7±0.1	Fair	7±0.1	Good	5.4±0.2	Fair
8	8	Very good	5.1±0.2	Fair	5±0.1	Fair	6.7±0.2	Slight good	5±0.1	Fair
9	8	Very good	6±0.1	Slight good	5.6±0.2	Fair	6.9±0.2	Slight good	6±0.2	Slight good
10	8	Very good	5.1±0.2	Fair	4.9±0.2	Slight bad	5.4±0.2	Fair	4.9±0.2	Slight bad
11	8	Very good	5.6±0.3	Fair	5.1±0.3	Fair	6.7±0.3	Slight good	5.4±0.3	Fair
12	8	Very good	6±0.1	Slight good	6±0.1	Slight good	7±0.1	Good	6±0.1	Slight good
GM	7.9±0.08	very good	5.4±0.1	Fair	5.3±0.1	Fair	6.8±0.1	Slight good	5.4±0.08	Fair

*scores using 9 point hedonic scales (9= excellent, 8= very good, 7=good, 6= slight good, 5=fair, 4= slight bad, 3= bad, 2= very bad, 1=extremely bad) * OAA= Over all acceptability.

Table 3. Weekly incidence of coliforms, fecal coliforms and *E.coli* in camel's milk samples.

Weeks	Total coliforms Positive samples		Fecal coliforms Positive samples		*E.coli* Positive samples	
	No.	%	No.	%	No.	%
1st W	5	71.4	3	42.8	2	28.6
2ndW	6	85.7	5	71.4	3	42.8
3rd W	7	100	3	42.8	3	42.8
4th W	7	100	-	-	-	-
5th W	7	100	2	28.6	-	-
6th W	7	100	3	42.8	2	28.6
7th W	7	100	-	-	-	-
8th W	7	100	-	-	-	-
9th W	6	85.7	-	-	-	-
10tW	6	85.6	1	14.3	1	14.3
11tW	6	85.6	5	71.4	5	71.4
12tW	2	28.6	2	28.6	2	28.6

Table 4. Frequency distribution of positive camel's milk samples based on their coliforms, fecalcoliforms and *E.coli cfu/ml.*

Weeks	Total coliforms								Fecal coliforms				*E.coli*			
	<10		$<10^2$		$<10^3$		$<10^4$		<10		$<10^2$		<10		$<10^2$	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1st W	2	28.6	3	42.8	-	-	-	-	2	28.6	1	14.3	1	14.3	1	14.3
2ndW	-	-	1	14.3	3	42.8	2	28.6	2	28.6	3	42.8	3	42.8	-	-
3rd W	-	-	1	14.3	5	71.4	1	14.3	-	-	3	42.8	-	-	3	42.8
4th W	2	28.6	3	42.8	1	14.3	1	14.3	-	-	-	-	-	-	-	-
5th W	-	-	-	-	2	28.6	5	71.4	1	14.3	1	14.3	-	-	-	-
6th W	-	-	2	28.6	2	28.6	3	42.8	3	42.8	-	-	2	14.3	-	-
7th W	-	-	5	71.4	2	28.6	-	-	-	-	-	-	-	-	-	-
8th W	-	-	3	42.8	1	14.3	3	42.8	-	-	-	-	-	-	-	-
9th W	-	-	4	57.1	2	28.6	-	-	-	-	-	-	-	-	-	-
10tW	-	-	-	-	1	14.3	5	71.4	-	-	1	14.3	-	-	1	14.3
11tW	3	42.8	2	28.6	1	14.3	-	-	5	71.4	-	-	5	71.4	-	-
12tW	-	-	2	28.6	-	-	-	-	1	14.3	1	14.3	2	28.6	-	-

Sensory analysis is a powerful tool in its own right for quality assurance (Q A). However coupling sensory analysis with chemical and microbiological analysis data can provide even more insights than using either technique alone. Total coliforms recorded the lowest count (28.6%) in the 12th week and it had the best scores for taste, odor, flavor and over all acceptability. Similar sensory score were recorded for milk samples of the 4th, 7th, 8th and 9th. These samples were negative fecal coliforms and *E. coli* and this give an indication that sensory evaluation could be guide for the microbiological level of milk. Color of milk in this study couldn't be used for the judgment as it record high score for all samples This may be attributed to the low content of carotene (Wernery, 2006); also camel's milk fat completely homogenized giving the milk a smooth white appearance (Abu-lehia, 1998). In the current study there is no relation between chemical and sensory parameters and they are completely independent.

Conclusion

In the present study on limited number of animals, fresh camel's milk had good nutritional values and unique flavor, sensory attributes as color, taste, flavor, odor and OAA. Extensive studies are needed to establish Egyptian standard of chemical parameters for camel's milk. So, it is strongly recommended to apply milking protocol, hygiene measures and sanitization programs to control the contamination of camel's milk during collection, storage, transportation as required for any other milk destined to human consumption.

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