Evaluation of physicochemical properties and microbiological quality of camel milk from Egypt

Abstract
So far, there has been little available literature regarding the quality and safety of consumed raw camel milk. Therefore, the present study was delineated to assess the physico-chemical properties and the bacterial contaminants of camel milk being collected from different geographic locations in Egypt. A total of 150 of raw camel milk samples were purchased from three different Egyptian Governorates during the period between September 2015 to August 2016. The collected samples were used for evaluating physicochemical properties, microbiological analysis. In general, a great variation in the chemical composition was found in the present study. Out of the tested milk samples, 133 were found to be contaminated with the total bacterial count, 69 samples were found to be contaminated with total coliform with a mean count of 3.70x10^3±1.20x10^4, 51% of the examined samples were found to be contaminated with Enterobacteriaceae with mean count of 2.91x10^2±6.20x10^2 cfu/ml, 57 samples were found to be contaminated with staphylococcus spp. while staphylococcus aureus was identified in only 22 samples with an average of 7.30x10^2±6.60x10^2 cfu/ml. The results herein indicated that camel milk had inferior microbiological quality due to its high contents of total bacterial counts, total coliform, total Enterobacteriaceae and staphylococcus spp. which are not in conformity with the official standards. These pathogenic germs can limit the keeping quality and safety of raw camel milk. There is a pressing need to improve the hygienic condition and providing adequate sanitary measures from the stage of production till milk consumption.

Keywords: camel milk, bacterial counts, chemical composition, sanitary assessment, public health hazards

Introduction
Camelus dromedarius, one-humped camel, plays a significant socio-economic role in dry and semi dry zones of Asia and Africa. For thousands of years, camels have been integrated into the daily life of nomads and reared under harsh conditions. Currently, camel remains a highly valued animal for its meat, milk, wool, skin, and folk medicine. It also serves as a mean of transportation, sport as well as a source of pride and wealth. The population of the Arabian one-humped camel is approximately 25 million, of which, 159 thousands raised in Egypt. Camel milk is considered as an integral source of food in Egypt particularly for nomadic people who live in arid regions such as Kirdasa, Ismailia, Matrouh and Shalateen. The value of camel milk has recently received a particular attention worldwide due to its high therapeutic value for human health. Camel milk is unrivaled from other ruminant milk in terms of composition as it contains high concentrations of immunoglobulin’s and insulin, high levels of essential elements such as sodium, potassium, iron, copper, zinc and magnesium and vitamins especially thiamine (B1), riboflavin (B2) and ascorbic acid (C) but low in protein, sugar and cholesterol. Various therapeutic properties have been reported for camel milk including anti-hypertensive, antioxidant, antimicrobial, immunomodulatory and anti-thrombotic. It has also been therapeutically used to combat various diseases such as dropsy, jaundice, tuberculosis, asthma and leishmaniasis. Pastoralists often consume this milk in a raw state either fresh or in varying degrees of sourness thereby representing a major concern for public health and is likely cause food-borne diseases. Although camel milk has received a growing interest during recent years, there has been paucity information regarding its quality and the potential bacterial contamination. Therefore, the purposes of this study were to assess the sanitary, physico-chemical composition of camel milk being collected from three different Egyptian Governorates as well as to evaluate its bacterial contaminants.

Materials and methods
Sampling
A total of 150 samples of raw camel milk were purchased from three different Egyptian Governorates (Giza, Matrouh and Shalateen) during the period from September 2015 to August 2016. The milk samples were aseptically taken in its commercial packages, labeled, and placed in cool box then transported to the laboratory of Food Hygiene and Control, Faculty of Veterinary Medicine, Mansoura University. The collected samples were divided aseptically into three portions to be used for sanitary analysis, chemical analysis and for microbiological analysis.

Physico-chemical properties of camel milk
The titratable acidity of the collected milk was determined according to the standard methods described by Official methods of analysis. The pH, dry matter, fat content, ash, total solids (T.S), solids not fat (S.N.F), lactose and protein of milk samples were measured using Lacto scan (MCCW Milk Analyzer, 8900 Nova Zagora, Bulgaria using). The percentage of moisture was also calculated by subtracting total solids (T.S) % from 100.

Microbiological analysis
Milk samples were subjected to microbiological examination to
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In this study, we aimed at evaluating the physicochemical characters as well as the microbial contaminants of camel milk being collected from different areas in Egypt. Here, the physical properties of the examined milk samples were presented in Table 1. In short, the values of milk pH were ranged between 4.96-7.06 with the highest grand mean value of pH was 6.61 with standard error of 0.04 in the milk purchased from Giza. According to Food Agriculture Organization, the value of pH in fresh camel milk is ranged between 6.5-6.7. The pH value recorded in the present study was consistent with those reported in Egypt by several authors with respective values of 6.65, 6.64, 6.6, and 6.6. In contrast, other researchers have reported lower values (5.43, 5.97, and 5.87), respectively. Similar pH values were also reported in other studies from different countries. It has been reported that the pH value could play a significant role in determining the product quality. The titratable acidity of camel milk is the measure of lactic acid formed in camel milk. In the present study, the acidity among the examined samples was varied from 0.09-0.30% W/V, the highest grand mean value of the titrateable acidity was 0.18% with standard error of 0.006 in the milk purchased from Shalateen area. Some of the examined samples, in particular, those from Shalateen express relatively a low pH value with high titratable acidity being attributed to the production of lactic acid by microbial flora. That was more likely during the summer season where ambient temperatures were relatively high and the lack of refrigeration for several hours during milk transportation.

Results and discussion

Camel milk has been acknowledged for long time as a white gold of the desert because of its valuable nutritional and medicinal properties. The results for bacterial enumeration were logarithmically transformed into log10 for statistical analysis. The statistical analysis was done using ANOVA and Chi-square. The different microbial variables were performed using SPSS software (Version 10, SPSS Inc., Chicago, USA).

### Statistical analysis

The presence of various microbial groups in the examined raw camel milk was summarized in Table 5–7. In short, the total bacterial count was varied from 1.91 x10^7 to 4.68 x10^7 cfu/ml with an average of 1.82 x10^7 and standard deviation of 3.87 x10^6 cfu/ml. Generally most of the milk samples were given in Table 4. In general, a great variation in the chemical composition of camel milk was found in the present study. It becomes clear that the overall milk composition can be influenced by several factors including physiological stage, feeding strategy, feed and water quality and quantity, seasonal variations, genetic, breed variation (within a species, herd to herd), stage of lactation and the health status. This view was in line with that given in several studies.

### Composition analysis of camel milk

The results of chemical composition as well as the averages values of the examined samples were summarized in Tables 2, Table 3. Briefly, the percentages of chemical variables were ranged as follow: T.S (5.90–20.51), proteins (1.10–9.87), fat (1.36–7.00), lactose (2.27–7.15), ash (0.35–1.24) and moisture (79.00–94.10). The chemical composition of camel milk samples from previous literature in Egypt were given in Table 4. In general, a great variation in the chemical composition was found in the present study. It becomes clear that the overall milk composition can be influenced by several factors.
tested samples (133/150) were found to be contaminated with the total bacterial count exceeding 10^5 cfu/ml. In that context, nearly similar results were previously reported by several authors elsewhere. In contrast, a lower bacterial burden was given in other studies. In fact, the TBC of camel milk has been reported with values varied from 10^3 to 10^5 cfu/ml. The high TCB of the tested milk samples could be likely attributed to improper handling of the samples during collection, transportation, or even during storage.

| Source             | Fat Mean±SE | Protein Mean±SE | Lactose Mean±SE | T.S Mean±SE | S.N.F Mean±SE | Ash Mean±SE | Moisture Mean±SE |
|--------------------|-------------|-----------------|-----------------|-------------|---------------|-------------|-----------------|
| Giza (n=50)        | 3.75±0.15a  | 2.61±0.11ab     | 4.59±0.15a      | 11.65±0.36a | 7.90±0.23a    | 0.70±0.01b  | 88.6±0.71a      |
| Matrouh (n=50)     | 3.79±0.17a  | 3.11±0.08ab     | 4.81±0.15a      | 12.40±0.37a | 8.60±0.23a    | 0.69±0.01b  | 87.74±0.34a     |
| Shalateen (n=50)   | 2.57±0.15a  | 2.34±0.20ab     | 4.69±0.12a      | 10.31±0.36a | 7.74±0.22a    | 0.73±0.02a  | 89.69±0.36a     |
| P value            | 0.0001      | 0.0004          | 0.5399          | 0.0003      | 0.0208        | 0.0863      | 0.0079          |

1-1 Variables with different superscript within the same column are significantly different at P ≤ 0.05

Table 3 Statistical analysis results of chemical examination of examined samples from Egypt (n=150)

Table 4 Exhaustive references (n =18) on camel milk composition from the literature in Egypt

Total *coliform* and *Enterobacteriaceae* count

In the present study, a total of 25 out of 69 (36%) of examined milk samples were found to be contaminated with total *coliform*, the maximum count was 1.65x10^8 with a mean count value of 3.70x10^5±1.20x10^5 (Table 5–7). Our findings were nearly similar to those given by El-Ziney MG et al. However, several authors have reported lower levels of contamination rate. On the contrary, a high mean count was determined by others. On the other side Bassuony IN et al., reported a much higher detection rate of *coliforms* (85.7%) out of 35 raw camel milk samples from Matrouh Governorate, Egypt. Our findings demonstrated that 51% of the examined samples were found to be contaminated with *Enterobacteriaceae* with mean count of 2.91x10^5±6.20x10^5 cfu/ml with a maximum count of 6.70x10^5 cfu/ml. In the same context, comparatively various counts were recorded in several studies. The *Enterobacteriaceae* and *coliform* bacteria being identified in the tested milk samples are considered as indicators of a potential fecal contamination. It has been reported that the existence of high numbers of these bacteria is commonly used as an indicator of poor hygiene, improper handling. It is also remarkable to underline that food poisonings cases may happen when the numbers of theses bacteria is increased.

In the present study, 57 out of 150 raw milk samples were found to be contaminated with *staphylococcus spp*. with maximum count of 3.20 x10^5 cfu/ml and mean value of 7.70x10^4±2.60x10^4. Importantly, *staphylococcus aureus* was identified in only 22 samples out of 57 staphylococci with an average of 7.30x10^4±2.60x10^4 while the maximum count was 2.20x10^5 cfu/ml. Coagulate positive (CPS) and coagulase negative staphylococci were recovered in a percentage of 15 and 38, respectively and might be main reason for subclinical mastitis in dromedaries. Occurrence of staphylococcus sp. were previously reported by several authors. But higher average counts of *staphylococcus aureus* were previously identified by others. The presence of *S. aureus* in the examined raw milk samples could represent a potential health hazard. It has also been suggested that this bacteria represent the third most important cause of disease in the world among the reported food borne illnesses due to its capability to produce a wide range of heat stable enterotoxins. In general *S. aureus* can gain access to milk either by direct excretion from infected udders (clinical or subclinical staphylococcal mastitis) or by contamination from the environment during handling and processing of raw milk. Taken altogether, our results might indicate a poor sanitary condition under which the camel’s milk was produced,

Citation: Elhosseny M, Gwida M, Elsherbini M, et al. Evaluation of physicochemical properties and microbiological quality of camel milk from Egypt. J Dairy Vet Anim Res. 2018;7(3):92-97. DOI: 10.15406/jdvar.2018.09.00197
as well as an environmental contamination through several sources including contamination of the camel udder, mixing of evening and morning milk, pooling of milk from different suppliers and exposure during marketing. Hence, the consumption of raw camel milk could be a potential public health concern and is likely to cause food-borne diseases and the natural antimicrobial factors can only provide a limited protection against specific pathogens.

Table 5 Comparisons of bacterial load of examined raw camel milk samples collected from some Governorates in Egypt

| Giza (n=50) | Matrouh (n=50) | Shalateen (n=50) |
|------------|----------------|------------------|
| **Total bacterial count** | 50 | 100 | 1.91x10^8 |
| **Total coliform count** | 22 | 44 | 3.03x10^8 |
| **Total Enterobacteriaceae count** | 24 | 48 | 7.20x10^7 |
| **Staphylococcus spp. count** | 17 | 34 | 3.20x10^5 |
| **Staph. Aureus count** | 6 | 12 | 1.70x10^5 |

Table 6 Statistical analysis results of bacteriological examination of raw camel milk samples (n=150) collected from some Governorates in Egypt

| Microbial counts | positive | Minimum | Maximum | Mean±SE |
|------------------|---------|---------|---------|---------|
| Total bacterial count | 150 | 100 | 1.91x10^8 | 4.68x10^6 | 1.82x10^5±3.87x10^6 |
| Total coliform count | 69 | 46 | ND | 1.65x10^4 | 3.70x10^4±1.20x10^4 |
| Total Enterobacteriaceae count | 77 | 51 | ND | 6.70x10^3 | 2.91x10^3±6.20x10^3 |
| Staphylococcus count | 57 | 38 | ND | 3.20x10^4 | 7.70x10^4±2.60x10^4 |
| Staph. aureus count | 22 | 15 | ND | 2.20x10^4 | 3.20x10^4±6.20x10^4 |

Table 7 Distribution of different bacterial counts in raw camel milk collected from some Governorates in Egypt

| No. of positive samples | 103<106 | 106<109 | 102<104 | 104<106 | 10<104 | 104<107 | 1<103 | 103<106 | 1<103 | 103<105 |
|-------------------------|---------|---------|---------|---------|--------|---------|-------|---------|-------|---------|
| % | 11 | 89 | 16 | 35 | 15 | 31 | 9 | 29 | 7 | 7 |

Conclusion

The results herein indicated that camel milk had inferior microbiological quality due to its high contents of total bacterial counts, total coliform, total Enterobacteriaceae and staphylococcus spp., which are not in conformity with the official standards. These pathogenic germs can endanger the keeping quality and safety of raw camel milk. There is a pressing need to improve the hygienic condition and providing adequate sanitary measures from the stage of production till milk consumption. On the other side, food safety education should be raised to camel milk producers, handlers and consumers with a recommendation of pasteurization of consumed raw camel milk.

Ethics

The work did not involve experimental animals or human subjects. As such it was exempted from institutional ethical clearance.

Acknowledgements

None.

Conflicts of interest

Author declares there is no conflict of interest.

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Citation: Elhosseny M, Gwida M, Elsherbini M, et al. Evaluation of physicochemical properties and microbiological quality of camel milk from Egypt. J Dairy Vet Anim Res. 2018;7(3):92–97. DOI: 10.15406/jdvar.2018.09.00197
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