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ASSESSMENT OF HYGIENIC QUALITY OF CAMEL (Camelus dromedarius) MILK IN KHARTOUM STATE, SUDAN

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EVALUATION DE LA QUALITE HYGIENIQUE DU LAIT DE DROMADAIRE (Camelus dromedarius) DANS L’ETAT DE KHARTOUM AU SOUDAN

Résumé

Au total, 112 échantillons de lait de dromadaire ont été collectés entre décembre 2004 et juin 2005, afin d’évaluer la qualité hygiénique du lait cru de dromadaire dans deux localités de l’Etat de Khartoum au Soudan. Pour ce faire, on a effectué les comptages des floras microbiologiques ci-après : le dénombrement total de bactéries, d’organismes mésophiles, de bactéries psychrotrophiques et coliformes, les nombres d’E. coli, de Staphylococcus spp. et de champignons. Aucune différences significative n’a été constatée en comparant les deux localités en ce qui concerne le dénombrement de bactéries, d’organismes mésophiles et de champignons. Le Nil oriental avait enregistré un nombre élevé (P<0.05) de bactéries coliformes, d’E. coli et de Staphylococcus spp. Parmi les 112 échantillons de lait de dromadaire collectés, E. coli, Staphylococcus spp. et le champignon ont été signalés dans 33 (29,5%), 46 (41%) et 32 (28,6%) des échantillons respectivement. En outre, les bactéries psychrotrophiques n’ont pas été aperçues au cours de l’étude, ce qui est peut-être dû au manque de matériel de réfrigération chez les communautés nomades. Même si le lait cru de dromadaire constitue l’aliment de base des pasteurs, les résultats de la présente étude ont montré que dans l’ensemble le lait cru de dromadaire est de qualité médiocre et qu’il y a une variabilité des échantillons quant à la qualité hygiénique. Toutefois, aucun cas de maladie n’a été signalé chez les pasteurs au Soudan suite à la consommation de lait cru de dromadaire.

Mots-clés : Lait de dromadaire, qualité microbiologique, Etat de Khartoum, Soudan.

Summary

A total of 112 individual camel milk samples were collected during the period from December 2004 to June 2005 to evaluate the hygienic quality of raw camel milk in two locations of Khartoum State, Sudan. To achieve this the following microbiological counts were done: total bacterial counts, mesophilic counts, psychrotrophic count, coliform counts, E. coli counts, total Staphylococcus spp. counts and yeast- mold counts. Non-significant differences were reported when comparing the two locations in total bacterial counts, mesophilic counts and yeast- mold counts. Eastern Nile scored significantly (P<0.05) high coliform counts, E. coli counts and Staphylococcus spp. counts. Of the 112 camel milk samples E. coli, Staphylococcus spp. and yeast- mold were reported in 33 (29.5%), 46 (41%) and 32 (28.6%) camel milk samples, respectively. Moreover, psychrotrophic bacteria were not reported during this study, which can be explained by the lack of cooling facilities among the nomadic communities. Despite of it been the major stable food for the pastoralists, the overall result obtained from the current study suggested that raw camel milk is of poor quality with presence of great variability among the milk samples regarding the hygienic quality. However, no outbreak causes reported by the consumption of raw camel milk among the pastoralist in Sudan.

Keywords: Camel milk, microbiological quality, Khartoum State, Sudan.
Introduction

Camels (*Camelus dromedarius*) are animals with special importance for nomadic herders in Sudan, as they are milk providers, which is often the only regular food source for camel owners for a considerable period of the year. Usually most of this milk is consumed fresh. Milk is synthesized in specialized cells of the mammary gland and is virtually sterile when secreted into the alveoli of the udder. However, raw camel milk may contain microorganisms, which are pathogenic for man. As milk leaves the udder of healthy animal, it normally contains very low number of microorganisms and further hazards stem from the adventitious contamination of raw camel milk by pathogenic bacteria from external sources from the udder like salmonella and campylobacter strains. Those strains produce many outbreak of enteritis. Pathogenic bacteria may also be present in raw camel milk as direct consequence of udder disease especially mastitis. Generally the microbial contamination in raw milk occurs from within the udder (diseases), exterior of the udder, and the surface of the milk handling equipment. Moreover, the skin of the udder, tick wounds on the teats and milker’s hand, especially if unwashed perfectly before milking or with wounds, are among the sources of contamination. Besides, the dust and flies at the milking site, especially if milk containers were left open, also the use of dirty water for milking process are among the source of contamination. Being a major constituent of nomadic diet, healthy camel milk production is considered essential to their health and welfare. However, nomads have shown very little interest to whether food and drink are good detrimental to their health, as their concern being only to have enough food. Moreover, in developing communities food-borne pathogens are responsible for million of cases of infectious gastrointestinal diseases each year. Food-borne pathogens are the cause of major public health problems worldwide. To date, around 250 different food-borne diseases have been described, and bacteria are the causative agents of two thirds of these disease outbreaks. Investigations showed that camel milk is highly contaminated when milked under nomadic conditions. The present study aims to determine raw camel milk hygienic quality at udder level, through the assessment of counts of total microbial flora (aerobic plate count, mesophilic bacterial counts and psychrotrophic bacterial counts), faecal contamination flora (coli form count), potential pathogens (*E. coli* and *staphylococci spp.*) and yeast-mold counts.

Material and methods

Source of samples and microbiological examination

This study was carried out during December 2004 to June 2005. After perfectly washing the udder, approximately 20 ml of quarter milk samples (n = 112) of camel milk were collected in sterile bottles from 56 camel in two different locations (Eastern Nile and Western Omdurman) of Khartoum State, Sudan. Samples were immediately labeled, stored in icebox and transferred within 2 hours to the laboratory. According to the procedure outlined by Houghtby *et al.* and the manufactures instructions, total bacterial counts, mesophilic bacterial counts and psychrotrophic bacterial counts were determined by pour plating appropriate dilution of milk samples in duplicate on plate count agar (Merck, Darmstadt, Germany). Plates were incubated at 32°C for 48 hours.
35° C- 48 hours and 7° C- 7-10 days, respectively. For the determination of the total coliform counts, *Escherichia coli* counts and *Staphylococcus spp.* counts appropriate dilution of the milk samples were spread on MacKonkey agar (Biomark, Pune, India), Violet Red bile agar (LABM, International Diagnostic Group, Bury Lincashire, U.K.) and Manitol salt agar (Oxoid, Hampshire, England), the plates were incubated at 32°C for 48 hours, respectively. Yeast- molds count was done on Yeast Extract agar (Biomark, Pune, India), after incubation at 25° C for 7 days. All counts were done in duplicates and the counting was done manually by using colony counter and reported as colony forming unit per milliliter (cfu/ ml). The total number of the colonies in the selected dilution was multiplied by the reciprocal of the dilution.

**Identification of the organisms**

The isolates of *Escherichia coli* and *Staphylococcus spp.* were Gram stained and subjected for motility and catalase test, acid production and oxidation fermentation (OF) test were also done. Moreover, Indole test, citrate utilization, fermentation of sugars (maltose, Manitol, lactose), Methyl Red (MR), Voges- Proskaur (VP) and tube coagulate test were done as secondary confirmatory tests.

**Results and discussion**

The mean total bacterial count of camel milk samples collected from two locations of Khartoum State was 1.22×108 cfu/ml. It was found to be higher when compared to those reported previously\(^{11, 25, 26}\). This high total counts mean indicates low quality of some raw camel milk. Measurement of bacterial number in milk is of interest, because they are indicators of poor milk hygiene\(^{27}\). Because of its properties\(^{28, 29}\), camel milk bacteriology is relevantly different in comparing to milk from other species\(^{25, 30}\).

The total bacterial counts of camel milk samples collected in Eastern Nile revealed mean total count of 1.36×108 cfu/ml (Table 2) with non-significant differences (P=0.05) when compared to that of camel milk samples collected from Western Omdurman (1.08×108). These more or less similar values might indicate that camel owners in both locations practice the same management procedure. Similarly, non-significant differences for mesophilic counts (5.02×107 cfu/ml and 5.27×107 cfu/ml) for Eastern Nile and Western Omdurman, respectively. This may also indicate similar management and practices. The mean mesophilic bacterial count of camel milk samples collected from Khartoum State was 4.86×106 cfu/ml.

The psychrotrophic bacteria were not reported during this study, which could be due to the lack of cooling facilities for camel owners in these two locations. Moreover, the samples were collected directly from the udder, with very low probability of contamination.

The mean coliform bacterial count of camel milk samples collected from Khartoum State was found to be 1.70×107 cfu/ml. This count was higher in compare to those reported previously\(^{11, 25, 26}\). The camel milk samples collected from Eastern Nile showed higher coliform counts in compare to that collected from Western Omdurman (Table 2). This high coliform count in Eastern Nile may be due to that some camels are kept in farms with dairy cattle, this may be source of contamination and transmission of infections, specially mastitis, through manual milking, this supported the previous report which stated that high coliform counts are due to contamination with feacal material, improper sanitation and/or mastitis.
infection\textsuperscript{10}.

Of the 112 raw camel milk samples obtained during this study, only 33 (29\%) showed the presence of \textit{E. coli} (Table 1). The mean \textit{E. coli} counts in camel milk samples collected from Khartoum State was found to be 9.92x10\(^6\) cfu/ml. However, the average \textit{E. coli} counts obtained in Eastern Nile was significantly (P= 0.05) higher than that obtained from Western Omdurman (Table 2). This might also indicate contamination with faecal material, especially during summer because of the relatively high rate of diseases including enteritis\textsuperscript{8}. Moreover, the high counts of \textit{E. coli} might be present in raw milk as a consequence of mastitis; this species is responsible for several different diseases for man of varying severity\textsuperscript{12}.

The mean \textit{Staphylococcus} spp. counts of camel milk samples collected from Khartoum State was 3.08x10\(^7\) cfu/ml. This mean was higher than that reported in the previous reports\textsuperscript{11, 26}. The minimum and maximum values were 0 and 3.10x10\(^7\) cfu/ml respectively (Table 2). In this study 46 (41\%) positive \textit{Staphylococcus} spp. cases were reported (Table 1) of which 21 were from Eastern Nile and 25 were from Western Omdurman. The camel milk samples collected from Eastern Nile revealed mean \textit{Staphylococcus} spp. count of 3.55x10\(^7\) cfu/ml, while those collected from Western Omdurman showed 2.21x10\(^7\) cfu/ml.

\begin{table}[h]
\centering
\caption{Comparison of incidences and frequencies of microbial quality of camel milk samples collected from Eastern Nile and Western Omdurman in Khartoum State, Sudan}
\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Location} & \textbf{\textit{E. coli}}} & \textbf{\textit{Staphylococcus} spp.} & \textbf{Yeast-molds} \\
\hline
Eastern Nile & 18 (32.1\%) & 21 (45.7\%) & 15 (46.9\%) \\
Omdurman & 15 (26.8\%) & 25 (54.3\%) & 17 (53.1\%) \\
Khartoum State & 33 (29.5\%) & 46 (41.1\%) & 32 (28.6\%) \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\caption{Raw camel milk hygienic properties in the milk samples collected from two locations in Khartoum State, Sudan}
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline
\textbf{Location} & \textbf{Min} & \textbf{Maximum} & \textbf{Mean} & \textbf{Min} & \textbf{Maximum} & \textbf{Mean} \\
\hline
Eastern Nile & 1.10x10\(^4\) & 3.95x10\(^5\) & 1.36x10\(^6\) & 3.00x10\(^5\) & 1.08x10\(^6\) & \\
Coliform (cfu/ml) & 0 & 2.10x10\(^7\) & 2.30x10\(^7\) & 0 & 1.40x10\(^8\) & 1.09x10\(^9\) \\
\textit{E. coli} (cfu/ml) & 0 & 9.50x10\(^5\) & 1.28x10\(^6\) & 0 & 9.50x10\(^7\) & 7.06x10\(^8\) \\
\textit{Staphylococci app.} (cfu/ml) & 0 & 3.10x10\(^7\) & 3.55x10\(^7\) & 0 & 2.05x10\(^7\) & 2.21x10\(^8\) \\
Yeast-mold (cfu/ml) & 0 & 3.45x10\(^5\) & 2.80x10\(^5\) & 0 & 2.80x10\(^5\) & 2.28x10\(^5\) \\
\hline
\end{tabular}
\end{table}
significant differences (P= 0.05) were obtained when comparing the two locations. Pathogenic bacteria may be present in raw camel milk as direct consequence of udder infection, especially with \textit{S. aureus}\textsuperscript{28, 31}. \textit{Staphylococcal mastitis} poses more direct threat to public health\textsuperscript{23, 30, 32}, through the \textit{staphylococcal enterotoxins}, that produced by \textit{Staphylococcus aureus}, which is an extraordinary versatile pathogen causing a wide spectrum of mild to sever life threatening infection in human\textsuperscript{14, 19, 32}. Moreover, the present data showed that the yeast- molds count of camel milk samples collected from Khartoum State was $2.54 \times 10^4$ cfu/ml, which was higher than that reported previously\textsuperscript{11, 19, 25}. Samples collected from Eastern Nile and Western Omdurman showed significant differences (P= 0.05) when comparing the mean yeast- molds counts ($2.80 \times 10^5$ cfu/ml and $2.28 \times 10^4$ cfu/ml, respectively). These differences might be due to that camel owners in Eastern Nile keep their camel in dairy farm with cattle. Moreover, keeping camel with cow in the same farms might be responsible for disease transmission. Data concerning microorganisms' isolated from fresh raw camel milk showed highly significant differences (P= 0.01) between the two locations. The poor hygienic quality of camel milk obtained during the present study indicated the lower standard of management practiced by camel owners in Khartoum State. This necessitates the increase of awareness of camel herders on the production of hygienic milk\textsuperscript{33}. This is especially needed because of the well known nutritional and health benefits of camel milk in the nomads live\textsuperscript{4, 13}.

It was noticed that the knowledge of camel owners on health risk associated with milk consumption was low as it was revealed from the questionnaire conducted during the present study (data not shown), this supported the report which stated that the lack of awareness on health risks associated with milk consumption amongst nomadic communities needs to be addressed in order to safeguard their health\textsuperscript{30}.

The present study recommended that due to the importance of these organisms for the public health and food safety, an efficient screening for the prevalence in camel milk is urgently needed to safeguard the nomadic communities as camel milk is their main food source.

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