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Prevalence of Microbes in Raw Camel Milk – an Overview

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Abstract: *Camel milk is one of the most important nutritional source, as well as, a remedy for the population in many arid areas. Camel milk is mostly consumed as fresh or naturally fermented product, hence unpasteurized. However, camel raw milk can be contaminated at any step in milk production and processing, thus it may lose its quality and safety standards. The purpose of the present study was to determine the Prevalence of microbes in raw camel milk. Many scientific studies have shown that the bacterial contamination of camel raw milk can occur at four levels, within the udder, after harvest, from the surface of equipment used for milk processing, and during storage and transport. Milk removed from a healthy udder contains a very low concentration of microorganisms, usually less than 10 x 10^2 colony forming units of total bacteria per ml (cfu/ml). A camel with clinical or subclinical mastitis has the potential to shed large numbers of microorganisms in its milk. So that quarters from infected camels have the potential to shed more than 10 x 10^6 cfu/ml in the produced milk. In the traditional husbandry systems, poor management and low hygienic standards during milking lead to mastitis in camels. Autochthonous microorganisms from the exterior of the camel udder and teats can contribute to the contamination, as well as microorganisms that are derived from the environment in which the camel is housed and milked. However, the most important appears to be the contribution of microorganisms from teats soiled with manure, mud and feed. Furthermore, under tropical and subtropical conditions, characterized by a lack of cooling and higher temperature, camel raw milk can be become contaminated after milking by storage and transport, especially if farmers store their milk in low hygiene plastic containers, and by the use of contaminated water. In such situations, the bacteria are able to grow rapidly and reached total bacteria counts of up to 10 x 10^7 cfu/ml. The types of bacteria that grow and become significant depends on the initial contamination of the milk. In conclusion, camel health, environment, milking procedures, equipment sanitation, storage and transport conditions can influence the prevalence of microbes in raw camel milk.*

Keywords*: camel, mastitis, microbes, milking, milk storage, milk transport, public health, raw milk.*

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I. Introduction

Camel milk is one of the most important nutritional source, as well as, a remedy for the population in many arid areas, because it contains almost all the essential nutrients which are required under arid climate. However, camel milk has numerous minor components which have special bioactive properties **(Kaskous and Pfaffl, 2017)**. These are present at significant concentrations and are extreme important and beneficial for human diet and health **(kaskous, 2016)**. Therefore, camel milk is most consumed as fresh or naturally fermented product and hence unpasteurized **(Mehari *et al*., 2007; Matofari *et al*., 2013; Abera *et al*., 2016, Mwangi *et al*., 2016; Serda *et al*., 2018)**. But, camel milk is an excellent culture medium for the growth of microorganisms (**Zangerl, 2007; Matofari *et al*., 2013**) and non heat treated milk and raw milk products as the major factors responsible for illnesses caused by food borne pathogens (**De Buyser *et al*., 2001**). The milk of a healthy udder is practically sterile (**Johnson *et al*., 2015**) although the camel udder is protected by a variety of defence mechanisms like innate or specific immunity as well as physiological particularities and is contaminated only with the passage of the teat canal with germs (**Zangerl, 2007**). However, the entering germs in the milk come from the udder-and teat-surface, the stall, the feed, the milker, the air, the water and the milking equipments. The contamination of the camel raw milk becomes very high, if the udder health is not recognized, use of plastic containers for milking and storing, no hygienic measures were carried out during the milking, no water for cleanliness of the milker or the udder before the milking (**Mulwa *et al*., 2011**). During the milk transport, especially when the road is long, and bad and the milk is not cooled, the microbial content of the milk rapid multiplicities (**Mulwa *et al*., 2011**). Due to the above problems, it was shown that, low hygiene status of the camel milk production and handling, and lack of cost-effective post harvest handling technologies leads to prevent exploitation of camel milk potential in improving the livelihood of pastoral community (**Matofari *et al*., 2007**) and this restriction leads to losses high post-harvest quality and quantity, in particular physiochemical and

microbiological deterioration of milk (**Odongo *et al*., 2016**). The production of hygienically flawless milk and ready for processing places high demands on the camel farmer in animal husbandry, animal care and feeding via milk removal and milk treatment until delivery to the consumer. In the following chapters, causes of prevalence of microbes in the raw camel milk are presented and discussed.

II. Raw camel milk and Public health

Raw camel milk could be used to treat, mitigate or prevent health conditions including diabetes, autism, cancer, dementia, allergies and parasites **(kaskous, 2016)**. In Ethiopia, most of camel milk is consumed in the raw state without any heat treatments **(Eyassu, 2007; Mehari *et al*., 2007)**. In the Arabian Peninsula, consumption of unpasteurized camel milk is also common **(Omrani *et al*., 2015)**. Furthermore, fresh and fermented camel milk has been also used in India, Russia and Sudan for human consumption as well as for treatment of a series of diseases **(Kumar *et al*., 2016)**. On the other hand, some countries like united Arab Emirate, USA and Australia warned that camel raw milk was not generally recognized as safe or effective for the therapeutic uses. The Food and Drug Administration (FDA) in USA warned that if the camel farmer was going to market their product as a drug they needed to get federal approval, which would require the farm to provide scientific data demonstrating the safety and effectiveness of their product. Moreover, FDA warned that a consumption of camel raw milk is a health risk. Because it is associated with food borne illness caused by pathogens including Escherichia Coli, Listeria, Brucella, Staphylococcus and Salmonella **(Swinburne, 2017; Wernery *et al*. 2017)**. **Zimmermann (2016)** reported that one of the primary risks of camels milk is consumed in unpasteurized form. The Saint Louis Institute for conservation Medicine studied the consumption of camel milk in northern Kenya, where around 10% of people drink unpasteurized camel milk, exposing themselves to a number of animal-based pathogens. The study found a higher prevalence of pathogenic bacteria in camel milk than in sheep and cattle milk. Furthermore, **Musinga *et al*. (2008)** found that contaminations of camel raw milk in Kenya can occur along the chain from producers to final consumers and the consumption of camel raw milk should be of major concern from public health. Some studies have shown that camel brucellosis has been diagnosed in all camel-rearing countries except Australia and depends on the management system **(Wernery, 2014)**. **Matofari *et al*. (2013)** found in Kenya that salmonella enteric occurrence along the camel milk chain had an incidence of 13% with the highest being at the farm environment. The sources of this pathogen may constitute the risk factors that are associated with the prevalence in the environment. Camels, soil, water and pastoralists themselves are possible sources of contamination. In other investigations, it was found that, viral RNA Middle East respiratory syndrome Corona virus (MERS-CoV) has been detected in camels in different countries as Jordan, Kuwait, quatar, Oman, Saudi Arabia and the United Arab Emirates **(Alagaili *et al*., 2014; Chu *et al*., 2014; Meyer *et al*., 2014; Omrani *et al*., 2015)** (Table. 1). But no MERS-CoV antibodies were detected in dromedary camels from Australia, Canada, Germany, Japan, the Netherlands and the United State of America **(Meyer *et al*., 2014; Shirato *et al*., 2015; Omrani *et al*., 2015)**. Scientists investigated that human can be infected with MERS-coV after exposure to infected camels, and camels may act as a direct source of human MERS-CoV infection **(Memish *et al*., 2014)**. However, the MERS-CoV viruses isolated from dromedaries are genetically and phenotypically very similar or identical to those infecting humans **(Chan *et al*., 2014)**. In addition, a research group was interested in spike protein-mediated entry of bat-borne corona viruses into cells and advancement of specific serologic tests for antibodies against corona viruses **(Meyer *et al*., 2014)**. Furthermore, Scientists don't know whether infected camel milk can sicken people, but experts say the results are enough reason to warn against drinking camel raw milk, which is a widespread tradition in the Middle East **(Reusken *et al*., 2014)**.

Table no 1: Prevalence of MERS-coV antibodies in dromedary camels in some countries (according to **Omrani *et al*., 2015**, with some changes).

Country and author	**Number of sampling**	**Camel age**	**Positive %**
Canary Islands, Reusken et al., 2013a	105	17 aged<4 years 88 aged>4 years	14.4
Egypt , Chu et al., 2014	52	>6 years	92.3
Egypt, Perera et al., 2013	110	5-7 years	98.2
Egypt, Müller et al., 2014	43	>6 years	81.4
Ethiopia, Reusken et al., 2014	188	31 aged <2 years 157 aged >2 years	93 97
Jordan, Reusken et al., 2013b	11	3-14 months	100
Kenya, Corman et al., 2014	774	unknown	29.5
Nigeria, Reusken et al., 2014	358	>2 years	94
Oman, Reusken et al., 2013a	50	8-12 years	100
Qatar, Haagmans et al., 2014	14	unknown	100
Qatar, Farag et al., 2015	105	76 aged<1 year 29 aged>1 year	97

Saudi Arabia, Hemida et al., 2013	310	1-5 years	90.3
Saudi Arabia, Alagaili et al., 2014	467	unknown	82.7
Saudi Arabia, Memish et al., 2014	9	unknown	100
Somalia, Müller et al., 2014	86	unknown	83.7
Sudan, Müller et al., 2014	60	unknown	86.7
Tunisia, Reusken et al., 2014	204	46 aged <2 years 158 aged>2 years	30 54
UAE, Alexandersen et al., 2014	11	unknown	81.8
UAE, Meyer et al., 2014	651	151 Adult 500 2-8 years	100 97.2
UAE, Wernery et al., 2015	843	108 aged <1 year 340 aged 2-4 years 310 aged > 4 years 85 unknown	85.2 96.5 96.1 80.0
UAE, Al Hammadi et al., 2015	8	4-10 years	100

The new results from Saudi Arabia showed that MERS CoV is not horizontally widespread in dromedaries and its highest occurrence was within isolated herds **(Alfuwaires *et al*., 2017)**

III. Prevalence of microbes in the raw camel milk based on inflammation of the udder

The udder of the camel can get clinical or subclinical mastitis, like other dairy animals. A high percentage of subclinical mastitis in camels is reported by several authors **(Obeid *et al*., 1996; Almaw and Molla, 2000; Wanjohi *et al*. 2013; Niasari-Naslaji *et al*., 2016)** and the values varied between 15 and 70% **(Bhatt *et al*., 2004; Abera *et al*., 2010; Seifu and Tafesse, 2010; Alamin *et al*., 2013)**. It was shown that mastitis pathogens of the dromedary are the same as cultured from the mammary gland of bovines and these are Streptococcus agalatiae, Staphylococcus aureus, Coagulse- negative Staphylococcus, Streptococcus bovis, Streptococcus uberis, Streptococcus dysagalactiae **(Wernery *et al*., 2008)**. In the traditional husbandry systems, poor management and unhygienic milking lead to mastitis in camels **(Obeid *et al*., 1996; Almaw and Molla, 2000)**. The results from Golestan province in Iran have shown that out of 243 camel milk samples from individual quarters (95 milking camels), 18.1% were subclinical mastitis and somatic cell count values beyond 306 x 10^3 cells/ml could be considered as subclinical mastitis in camel **(Niasari-Naslaji *et al*., 2016)**. **Bekele and Molla, (2001)** reported that, out of 152 camels in Afar Region, north-eastern Ethiopia examined, 19 (12.5%) were diagnosed as clinical mastitis cases based on clinical signs and bacteriological examinations. The main mastitis pathogens isolated were Staphylococcus aurous, coagulate negative staphylococci, Streptococcus agalactiae, S. dysgalactiae, and other species of streptococci, pasteurella haemolytica and E. coli. Similar results have been shown by **Wanjohi *et al*. (2013)** that subclinical mastitis is prevalent in dromedary camels of two districts of North-Eastern province of Kenya, and that Gram-positive cocci (Staphylococcus and Streptococcus) are the dominant mastitis pathogens isolated. Other isolated bacteria were found as Klebsiella/Enterobacter, Escherichia coli and Bacillus. **Abdel Gadir Atif *et al*. (2006)** have performed comparison of California mastitis test (CMT), somatic cell counts (SCC) and bacteriological examinations for detection of camel mastitis in Ethiopia. A total of 956 quarter milk samples from 253 camels were detected. 59.7% quarter milk samples had microorganisms. A positive correlation was found between CMT scores and bacteriological classes ($P<0.001$). Strong correlation between CMT scores and SCC was also recorded ($p<0.001$). Detection of subclinical mastitis in dromedary camels using somatic cell counts, California mastitis test and udder pathogen was also done in Saudi Arabia **(Saleh and Faye, 2011).** A total of 120 quarter milk samples from 30 clinically healthy dromedary camels were cultured. SCC varied from 9000 to 2 000.000 cells/ml with an average of 125000. Intramammary infections were present in most of examined quarter milk samples. The following table presents the results of some works on contaminated udder quarters with microorganisms (Table. 2)

Table no 2: Positive prevalence of subclinical and clinical mastitis in some countries in dromedary camels.

Country and Authors	**No. quarter milk samples (camel)**	**Positive prevalence of Subclinical or clinical mastitis (%)**
Egypt, Asfour a. Anwer (2015)	90 from camel udder	87.78
Ethiopia, Abdel Gadir Atif *et al*. (2006)	956 (253 camels)	59.7%
Ethiopia, Abdurahman (2006)	205 (53 camels)	37.6%
Ethiopia, Abera *et al*. (2010)	145 camels	29%
Ethiopian, Abera *et al*. (2016)	47 samples from udder	76.60%
Ethiopia, Bekele a. Molla (2001)	543 (152 camels)	63%
Ethiopia, Hadush *et al*.(2008)	(34 camels)	5.88 %
Iran, Niasari-Naslaji *et al*., 2016	243 (95)	18.1%
Jordan, Hawari a. Hassawi (2008)	90 camels	21%
Kenya, Guliye *et al*. (2002)	86 (22 camels)	81.4%
Kenya, Matofari *et al*.(2013)	107 from camel udder	66%
Kenya, Odongo *et al*.(2016)	66 from camel udder	Most of examined quarter milk samples

Kenya, Toroitich *et al*. (2017)	380 (95 camels)	44.5%
Kenya, Younan *et al*. (2001)	(207 camels)	23%
Kenya, Wanjohi *et al*.(2013)	384 camel samples	61.2%
Saudi Arabia, Saleh and Faye (2011)	120 (30 lactating camels)	Most of examined quarter milk samples
Saudi Arabia, Al Jumaah *et al*. (2012)	740 (47 camels)	33 % of tested quarters had subclinical mastitis based on CMT
Sudan, Elhaj *et al*.(2014)	160 from camel udder	71.9%
Sudan, Abdurahman *et al*.(1995)	391 (101 camels)	43.5%

Usually, camels are milked by hand in most countries of the world in traditional farming systems. The introduction of machine milking makes only slow progress and is limited to intensive dairy camel farms in a few countries. Machine milking in camels must be spread in order to reduce many problems, especially contamination of camel raw milk. **Saleh *et al*. (2013)** showed a clear difference between the udder health status in the two sampled forms from two milking procedures. The microbiological contamination was higher in farm with hand milking than in farm with machine milking (Table. 3)

Table no 3: Bacteriological finding of camel udder milk samples in two farms with different milking procedures (**Saleh *et al*. 2013)**

Parameters	**Farm A (machine Milking)**	**Farm B (hand milking)**
Number of Camels	14	14
Duration of the investigation	6 Months after calving	6 Months after calving
Total samples testing	84 (100%)	84 (100%)
No growth (non infected)	65 (77.4%)	53 (63.1)
Coagulase-negative staphylococci	15 (17.8%)	22 (26.2%)
Staphylococcus aureus	-	3 (3.6%)
Micrococcus	4 (4.8%)	6 (7.1%)

But, some studies clearly showed that completeness of milking by machine with the available equipment is not satisfactory. The amount of residual milk after machine milking is high (up to 30% or even more) **(Kaskous, 2018)**. The remaining milk after milking may serve as a substrate for pathogens and increase the risks of mastitis **(Bruckmaier and Wellnitz, 2008)**. Special milking machines for camels are necessary, to allow a fast and complete milk removal and to maintain good udder health. Only then machine milking is efficient for the farmer and guarantees a milk production under high quality standards **(Kaskous, 2018)**. Siliconform company in Germany works on a project in this field. Now, the right milking machine for camels is ready to be used in the field (Figure. 1).

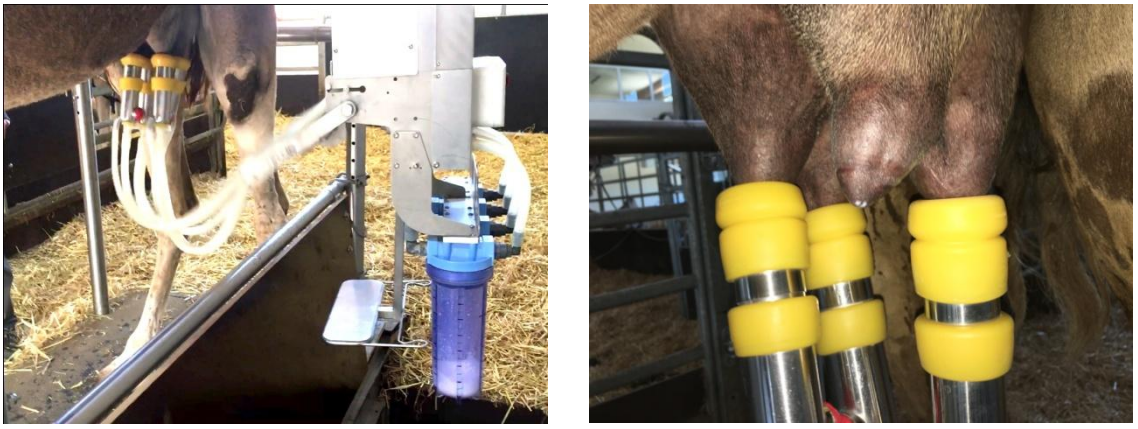

Figure no 1: StimuLactor (ST-C) for Camel during milking

In Algeria, **Yamina *et al*. (2013)** have checked whether the month of the year has an effect on the contamination of the camel raw milk or not. The microbiological analysis showed that the months have significant effect on the number of the total micro flora, staphylococcus aureus and total coli forms contamination of camel raw milk (Table. 4).

Table no 4: Bacteriological finding of camel udder milk samples in two different months **(Yamina *et al.* 2013)**

Parameters	**February**	**September**
Number of camels	10	10
Total aerobic mesophilic germs cfu/ml	30 ±3.4 x 10^4	40±2.2 x 10^5
Staphylococcus aureus cfu/ml	35±3.4 x 10	29 ±1.3 x 10
Total coli forms cfu/ml	20 ±2.4 x 10^2	40 ±4.2 x 10^2
Fungal flora	-	37±3.3 x 10^4

In Sudan (North of Khartoum), raw camel milk samples were collected and the isolated aerobic bacteria (115 isolates) were identified as Gram-negative (85.26%), while (14.73%) of samples were Gram-positive. The authors emphasize that raw camel milk is a source for many bacteria which may lead to health hazard for men **(Elhaj *et al.*, 2014)**. In south province of Jordan, raw milk samples were collected from 90 dromedary camels. About 21% of the camels revealed clinical signs of mastitis. The most predominant bacteria isolates were Staphylococcus aureus, Streptococcus spp. Micrococcus spp. and Corynebacterium spp. **(Hawari and Hassawi, 2008)**. The microbial quality of camels raw milk in United Arab Emirates was investigated, 50 samples were analyzed for: Aerobic plates count, total coliform, total staphylococcus aureus, total yeast and mold. The results indicated that the mean value of aerobic plate count 1.8 x 10^5 cfu/ml, mean value of total coli form 6.8 x 10^1, mean value of staphylococcus aureus 1.2 x 10^3, yeast mean value 4.1 x 10^{-1} cfu/ml **(Omer and Eltinay, 2008)**. Furthermore, it should also be noted that the calf may be a source of prevalence of microbes in camel milk. So in many countries, the calf will have their mother suckle to induce the milk ejection reflex. But the calf may compromise the udder hygiene since after suckling no cleaning of the udder before milking is done **(Noor *et al.*, 2013)**.

IV. Prevalence of microbes in the raw camel milk after harvesting

Raw camel milk is a natural food that can be contaminated with microbes in the chain from the milking to the consumer as the milk is very good suitable liquid for microbes. Therefore, a great deal of research has been done to determine the prevalence of microorganisms in the raw camel milk after milk removal from the healthy udder **(Wanjohi *et al.*, 2013; Matofari *et al.*, 2013; Odongo *et al.*, 2016; Serda *et al.*, 2018)**. Autochthonous microorganisms from the exterior of the camels udder and teats can contribute to the contamination as well as microorganisms that are derived from the environment in which the camel is housed and milked **(Bachmann,1992; Bekele and Molla, 2001; Hawari and Hassawi, 2008; Omer and Eltinay, 2008; Wanjohi *et al.*, 2013)**. However, most important it appears to be the contribution of microorganisms from teats soiled with manure, mud and feed. Teats and udders of camels inevitably become contaminated while they are lying or when allowed in dirty lots. The influence of dirty camels on total bacteria counts depends on the extent of soiling of the teat surface and the udder prep procedures employed. **Matofari *et al.*, (2013)** reported that camel milk is less contaminated at farm because it has not undergone many handlers. The only contamination at this stage may come from the infected udder mostly caused by the cocci group. **Abera *et al.*, (2016)** reported that the two dominant factors of the quality of camel raw milk after harvesting are the condition of keeping the product and the time before delivery to the consumer. High number of bacteria in aseptically drawn milk samples or detection of presence of harmful pathogenic microorganisms is an evidence of unhygienic milk production conditions **(Abdurahman, 2006; Kamal *et al.*, 2010)**. **Matofari *et al.*, (2013)** have found that 66% of the raw camel milk samples had microbial load less than 10^5 cfu/ml at production area, compared to 54% at bulking and marketing where the microbial load was over 10^6 cfu/ml. Furthermore, Common means of transporting raw camel milk from production areas in Kenya as example, about 10 to 20 km away to bulking or market centres are bicycles, donkeys and present vehicles and the ambient temperature in the production areas and at the transport way was about 39 °C. The camel raw milk reaches the nearest bulking centres in 2 to 3 h and to major markets in cities in 6 to 8 h **(Matofari *et al.*, 2013)**. In this transport process, the raw camel milk could get millions of microbes when the raw camel milk reaches the consumer, and therefore the raw camel milk poses a threat to consumer health. **Abera *et al.*, (2016)** found that about 85.7% of raw camel milk samples demonstrated bacterial contamination in Fafen Zone, Ethiopian Somali regional state and the total bacterial counts (TBC) and coliform counts (CC) of contaminated camel raw milk samples were 4.75±0.17 and 4.03±0.26 log CFU/ml, respectively, and these bacteria increased rapidly from udder to market. Around 38.9% of TBC and 88.2% CC in contaminated raw camel milk samples were in the range considered unsafe for human utility (Tab. 5).

Table no 5: Mean ± Standard error values of total bacterial counts, coliform counts and percentage of milk samples contaminated with difference microbes **(Abera *et al*., 2016).**

Parameters	**Sampling levels**		
	Udder	**Milking bucket**	**Market**
Total bacterial counts (log CFU/ml)	4.20±0.3	4.8±0.4	5.1±0.2
Coliform Counts (log CFU/ml)	3.5±0.4	3.7±0.5	4.3±0.4
Staphylococcus spp. (%)	100	100	78
Streptococcus spp. (%)	44.4	23.8	72.5
E. Coli (%)	13.9	52.4	35.3
Klebsiella spp. (%)	2.8	4.8	7.8
Enterobacter spp. (%)	0	0	11.8
Salmonella spp. (%)	8.3	19	23.5

The majority of the bacterial isolates in this study showed high incidence in market as compared to production level. **Odongo *et al*., (2016)** showed similar results in a study in Kenya and there was poor hygiene at the herd level, where high Staphylococcus aureus count was found on the camel udder swab, milkers hand swab, and milking container swab which recorded counts of 1.4×10^4 cfu/cm^2, 1.5×10^4 cfu/cm^2, and 5.9×10^3 cfu/ml, respectively. These results indicated that hygiene could be one of the most important contributors to milk deterioration along the chain (Table. 6).

Table no 6: Microbial counts (cfu/cm^2) of camel udder, milker's hands and milking containers at the herd level **(Odongo *et al*., 2016).**

Type of organism	**Camel udder swab**	**Hand swabs for milkers**	**Milking container swab**
	Geometric mean	**Geometric mean**	**Geometric mean**
Total viable counts	5.8×10^{5b}	6.5×10^{5b}	1.1×10^{5a}
Coliforms counts	4.6×10^{1a}	7.2×10^{2c}	4.5×10^{2b}
Staphylococcus aureus counts	1.4×10^{4b}	1.5×10^{4b}	5.9×10^{3a}

The generic mean values with similar letters in the same row are not significantly different at $p < 0.05$.

The table (6) clearly shows that the counts in swabs from milker's hands for all the three indicator organisms were higher, indicating that milkers demonstrated poor hygiene during milking, hence it could be the main source of microbial contamination of the camel milk. Furthermore, **Mohammed *et al*., (2016)** tested the milk quality of 130 camel milk samples in north-eastern Ethiopia, which were taken randomly from individual pastoralist milk sellers and at the same time each pastoralists were interviewed using a prepared structured questionnaire. From 130 examined milk samples, 88 (67.7%) were found to be culture positive and yielded at least one bacterium. The respondents' views were briefly summarized in Table (7).

Table no 7: Influencing factors on camel milk quality and safety during the production process **(Mohammed *et al*., 2016)**

Factors	**Categories**	**Number of respondents**	**%**
Awareness of raw milk health	Yes no	17 113	13.1 86.9
Udder health	Yes no	26 104	20 80
Hand washing before and after Milking	milking all camels Milking every camel	6 124	4.6 95.4
Milking order	Sequentially randomly	30 100	23.1 76.9
Udder hygiene	Yes no	10 120	7.7 92.3
Foremilk stripping	Yes no	17 113	13.1 86.9
Milking equipment hygiene	Cleaning with water Cleaning with smoke Cleaning with soap Cleaning with ash	45 58 8 19	34.6 44.6 6.2 14.6
Storage equipment hygiene	Cleaning with water Cleaning with soap Cleaning with ash Cleaning with towel Cleaning with water and smoke	40 7 19 1 63	30.7 5.4 14.6 0.8 48.5
Distance from milk source to market	5-6 hours 2-4 hours 1-2 hours	17 24 89	13 18.5 68.5

Milking equipment sharing	Yes no	40 90	30.8 69.2
Habit of drinking milk	Raw boiled	130 0	100 0
Milk cooling	Yes no	0 130	0 100
Barn cleaning	Yes no	0 130	0 100
Milk condition	Single pulled	35 95	26.9 73.1
Source of water	Tap water Untreated ground water river	23 36 71	17.7 27.7 54.6

The results of the questionnaire survey and the observations in the study area show that milk was generally produced by the pastoral communities under unhygienic environmental conditions with poor quality water. The milk was transported to the market taking longer time and using unclean plastic containers. In addition, the milk is consumed in its raw state. Furthermore, **Serda *et al*., (2018)** reported, that in the study area in Jigjiga District, Eastern Ethiopia camel milk is consumed (100%) in its raw state without any type of processing treatment and the camel raw milk was contaminated with Staphylococcus aureus. The prevalence of Staphylococcus aureus was 7.03%, 11.71% and 15% from household, primary collection centers and selling sites, respectively. However, Mwangi et al. (2016) reported on the main problems in the milk chain that inhibit having good and safe camel raw milk (Table. 8)

Table no 8: The challenges faced in the camel milk value chain (**Serda *et al*., 2018)**

Value chain node	**Challenges**
Production area	Lack of water
	Lack of cooling facilities
	Lack of hygiene in Personal, equipment and environment
	Mixing of milk from diseased camels with milk from healthy camels.
	Lack of veterinary service due to high mobility
Cooling centers	Lack of knowledge on hygiene and quality checks
	Lack of quality control tests
	Lack of clean water
	Problems with pooling milk
	Interrupted power supply to coolers
	Spoilage/unexpected fermentation of coming milk to the cooling centers
Transportation	Lack of refrigerated tankers for transporting the milk
	Poor state of roads
Marketing	Sale in open air-roadside
	Long distance to market
	Lack of cooling facilities
	Spoilage/unexpected fermentation

V. How to get a safe camel raw milk

Besides good design and management of the housing, there are several measures which can be implemented to improve the quality and safety of camel raw milk:

- Camels in the farm should be kept clean.
- The milking area must be sited and constructed to ensure satisfactory hygienic conditions during milking.
- All milking equipment must be kept clean in good condition at all times.
- It is better to use the milking machine for milk removal
- Presence of water in the milking area is quite necessary for cleaning of soiled teats and udders, equipment, hands, fittings and floors, during and after milking.
- Thorough cleaning of the teat followed by thorough drying is effective in reducing the numbers of bacteria in milk contributed from soiled teats.
- Open parlors can be accepted in situations where hygiene risks are minimized and very high standards of management are maintained.
- A sick animals must isolate from the healthy animals and the milk must come only from animals that are in a good general state of health.
- The plastic milk containers and other containers must be disinfected chemical sanitizes after washing
- After milking it is forbidden to mix the milk of sick animals with the milk of healthy animals and to fill in a container.

- After harvesting, refrigeration of raw camel milk is necessary during storage and transport. Because under conditions of poor cooling with temperature greater than 30 °C, bacteria are able to grow rapidly. Streptococci have been associated with poor cooling of milk. These bacteria will increase the acidity of milk.

VI. Conclusion

Camel health, environment, milking procedures, equipment sanitation, storage and transport conditions can be causes to prevalence of microbes in the raw camel milk which can be a risk to human health. Therefore, we recommend regarding the quality of raw camel milk and free of microbes as possible programs should be conducted to understand the behavioral risk factors associated with raw milk production and consumption. Raw camel milk intended for human consumption must be subjected to pasteurization in order to guarantee the quality of these highly camel product.

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