

# RISK FACTORS ASSOCIATED WITH PREVALENCE OF BRUCELLOSIS AND BACTERIA IN FERMENTED COW MILK OBTAINED FROM KAJIADO CENTRAL SUB-COUNTY IN, KENYA

## ABSTRACT

Cattle rearing remains to be among the most important activities practiced by Maasaipastoralists in Kajiado Central Sub-County, Kenya. However, its role has been hampered by occurrence of Brucellosis and other pathogenic conditions which has been recognized as an important public health concern. The present study assessed the prevalence and risk factors of brucellosis, and presence of pathogenic bacteria in fermented cow milk obtained from respondents in Kajiado Central Sub-County. The study design was a cross-sectional where 114 fermented milk samples were sampled from all wards in the sub-county. From each household, one fermented milk sample was obtained and assessed for brucellosis using milk ring test. The sampled milk was also transported to the laboratory where presence of other bacterial microorganisms was determined using standard bacteriological methods. Questionnaires were administered at farm level to assess the risk factors associated with occurrence of brucellosis. The overall prevalence of brucellosis in the fermented cattle milk was 7.89% and was reported in milk obtained from Purko (10%), Dalalekutuk (9.6%) and Matapato North (8.6%) wards of the sub-county. Herding of cattle with other livestock and use of communal bulls in breeding had a close association ( $p < 0.05$ ) with the prevalence of brucellosis. There were 7 bacterial species isolated from the milk and these included *Streptococcus* spp. (43.86%), *Lactobacillus* spp. (40.35%), *Klebsiella* spp. (15.79%), Coagulase Negative *Staphylococcus* (14.91%) *Pseudomonas* spp. (14.04%), *Staphylococcus aureus* (11.4%), *Salmonella typhi* (7.89%) and *Escherichia coli* (4.39%). The mean coliform count of the fermented milk ranged from  $1.61 \times 10^1$  to  $5.84 \times 10^1$  CFU/ML. In conclusion, the study showed that brucellosis, which is zoonotic in nature, is prevalent in the study area. There is a need to create awareness of occurrence of brucellosis and other pathogenic bacteria in fermented milk by addressing the observed risk factors.

**Keywords:** *Brucella* spp., cows, fermented milk, pathogenic bacteria, Kajiado, Kenya physiochemical properties

## 1. INTRODUCTION

Brucellosis is ranked as a top priority zoonotic disease due to the socio-economic burden and amenability to control (References???). However, as it is common with other neglected zoonotic diseases, establishing the true morbidity and socio-economic impact of the disease is a challenge because of misdiagnosis and underreporting (1). Studies in Kenya indicate the disease is endemic in humans and livestock although this varies with geographical region and

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livestock production system (2, 3). In domestic animals, the prevalence from pastoral and agro-pastoral herd range from 9.9-15% (4). Identifying potential risk factors of brucellosis among the most vulnerable populations; primarily rural livestock keeping communities is important in defining control and prevention strategies (3). In the pastoralist counties where the disease is endemic, there are limited scientific studies to determine the actual prevalence of brucellosis.

On the other hand, the ingestion of viable pathogenic bacteria along with food products such as milk leads to food borne infection (5). The bacteria previously isolated from milk of domestic animals amongst the pastoralists include *Salmonella* spp., *Mycobacterium bovis*, *Corynebacterium* spp., *Clostridium perfringens*, *Yersinia enterocolitica*, *Coxiella burnetii*, *Brucella* spp., *Staphylococcus* spp., *Campylobacter jejuni*, *Pseudomonas* spp., *Shigella* spp. and *Escherichia coli* (6,7,8). These microorganisms are usually associated with food borne diseases and outbreaks (9). The occurrence of these pathogenic bacteria in milk is a serious public health concern especially where unpasteurized raw milk is drunk (10). A recent study in Garissa County (Kenya) showed that prevalence of brucellosis in camel milk was 8% while other concurrent bacteria in the milk were *Pseudomonas* spp. (32.2%), *Salmonella* spp. (30.5%), *Staphylococcus* spp. (21.2%), *Escherichia coli* (8.5%) and *Shigella* spp. (7.6%) (6).

In Kajiado County (Kenya), the local Maasai pastoralists depend on cow's milk as a major source of proteins and other nutrients, where some drink it raw while others ferment it using traditional gourds to improve the nutritive value (11). Where fermented milk is prepared from raw milk, there are possibilities that it will still be containing pathogenic bacteria which were present in the raw milk (12). The local veterinary and medical officers indicate that risk factors for brucellosis are common but they have not been well documented. The current study aimed at determining the prevalence, risk factors of brucellosis, and other pathogenic bacteria in fermented cow milk from Kajiado Central Sub-County.

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## 2. MATERIALS AND METHODS

### 2.1 Study area

The study was undertaken in Kajiado Central Sub-County (Kenya) which is a semi-arid area, having an average annual temperature of 18.9°C (References??). This area receives about 500 mm of rainfall annually, most of it falling in April (References??). The Sub-County human population is 161,862 and has an area of 4,239.50 km<sup>2</sup> with number of households being 37,238 (13). The wards involved in the study were Purko, Ildamat, Dalalekutuk and Matapato North wards. The latest census shows that the number of cattle in Kajiado Central Sub-County was 95,534 (13).

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### 2.2 Study design and sampling strategy

The study design was cross-sectional. The sample size was estimated using the formula by(14). The estimated brucellosis prevalence was 8.0% based on a previous study in a pastoralist area (15). Based on the formula, a minimum of 113 respondents were to be sampled. In the current study, 114 households were randomly selected from different wards in the sub-county. A sampling frame was developed with the help of animal health officers in charge of their respective wards to ensure all areas are well represented.

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### 2.3 Questionnaire survey

The questionnaires were administered to respondents at farm level to gather information on biodata, livestock species kept, occurrence of livestock abortion, retained placenta in the livestock, consumption of unpasteurized milk, breeding system, herd size, herding system, and farm management activities.

### 2.4 Milk sample collection and determination of prevalence of brucellosis in fermented cattle milk

A total of 114 traditional fermented (*Kulenaotoin* local language) milk samples (15ml) were collected into sterile universal bottles, labeled, and then put in a cool box and transported to the JKUAT Microbiology laboratory where it was kept at temperature of 4°C.

The milk ring test was carried out for detection of brucellosis (16). Briefly, the test was conducted by addition of 30µl of antigen to 2ml of fermented cowmilk. The milk/antigen mixture was incubated for an hour at 37°C, and a control sample was also subjected to similar conditions. A positive reaction was indicated by the formation of a dark blue ring above the white milk column. The test was considered negative if the color of underlying milk remained homogeneously dispersed in the milk column (17).

### 2.5 Determination of other bacterial microorganisms present in cow milk

Each milk sample was cultured in six different agars (namely Mannitol Salt Agar (Hi media Ltd), Eosin Methylene Blue (Hi media Ltd), Salmonella Shigella Agar (Hi media Ltd), Nutrient Agar (Hi media Ltd), Pseudomonas Isolation Agar (Hi media Ltd), Man Raogosa Sharpe Agar (Hi media Ltd), Blood Agar (Hi media Ltd), Mac Conkey Agar (Hi media Ltd) and Nutrient Agar (Hi Media Ltd)) as described previously (18). Cultures were then put into an incubator for 24-48 hours at 37°C. Bacterial identification of isolated bacteria was done based on colony morphological features and gram staining reactions on pure cultures and biochemical tests such as indole, catalase, and oxidase tests.

### 2.6 Determination of coliforms in fermented cattle milk

The microbiological quality of fermented milk product was further assessed by spread plate method(19). The Violet Red Bile Glucose Agar was used to detect and enumerate Enterobacteriaceae in fermented milk (References??). Briefly, 1ml of the serial dilution was transferred to petri dishes using two plates for each dilution. The dishes were inverted

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and incubated for 24 hours at 37°C for coliform growth. The colony forming units (CFU) were then enumerated.

## 2.7 Data analysis and management

Data collected was coded and entered in MS Excel (Microsoft, USA). They were ~~coded, and~~ analyzed using ~~S~~statistical ~~P~~ackage for ~~S~~social ~~S~~ciences (SPSS, Microsoft, USA), ~~version~~ ~~YY~~ to generate descriptive statistics. The Chi-square test and ANOVA were used to determine the relationship between prevalence of pathogenic bacteria and various risk factors. ~~A significance level of 0.05 was used for all statistical tests. P was set as 0.05.~~

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## 3. RESULTS

### 3.1 Characteristics and knowledge of brucellosis amongst respondents

The characteristics of the sampled farmers are shown in Table 1. Most (68%) of the respondents were women and 40% of ~~these~~ respondents had not attained formal education. The majority (81%) of respondents kept a combination of cattle and other livestock species. These animals were reared in an extensive system of production. Over half (50%) of the respondents were not aware of the occurrence of brucellosis within the community. In terms of risks to transmission of brucellosis, 50% of the respondents consumed fermented milk which was prepared from raw milk. Farmers processed the milk through boiling (30%), while others (34%) undertook a combination of both boiling and fermentation. For the fermentation of milk, the respondents used the traditional gourd (*Enkunkuri*) which was smoked using traditional herbs, such as *Lantana ukambensis* and *Olea europaea* for fermentation and storage of the fermented milk.

A large number (70%) of respondents had experienced cases of retained placenta amongst their livestock. The placenta was either thrown away to the bush (30%), buried (14%) or given to the dogs (70%) for consumption. The respondents associated brucellosis in their herds as causing infertility (18%), abortions (30%), retained afterbirth (40%) and still births (26%).

**Table 1: Characteristics and knowledge of occurrence of brucellosis amongst respondents from Kajiado Central Sub County (Kenya)**

Attributes	Category	Frequency (N)	Percentage (%)
Gender	Male	46	40
	Female	68	60
Level of education	Never gone to school	40	35
	Primary	30	26
	Secondary	33	27

	Tertiary	11	12
<b>Method of processing fresh milk</b>	Boiling	30	26
	Fermentation of raw milk	50	50
	Boiling, Fermentation	34	28
<b>Knowledge on brucellosis</b>	Yes	64	56
	No	50	44
<b>Cases of retained afterbirth in cattle</b>	Yes	80	70
	No	34	30
<b>Disposal of placenta</b>	Throw away in the bush	30	26
	Bury	14	12
	Give to dogs	70	62
<b>Effects of brucellosis in the animals</b>	Infertility	18	16
	storm abortions	30	26
	Retained afterbirth	40	35
	Stillbirths	26	23

### 3.2 Prevalence of brucellosis

Out of the 114 cattle fermented milk examined, 9(7.89%) samples were positive for brucellosis (Table 2). For the 9 positive cattle milk samples, 3 (10.0%) originated from Purko Ward, 1 (9.6%) from Dalalekutuk Ward and 5 (8.6%) from Matapato North Ward (Table 2).

**Table 2: Prevalence of brucellosis as categorized by wards.**

Ward	Total sampled	No. Positive	Prevalence (%)
Purko	30	3	10.0
Illdamat	15	0	0.0
Dalalekutuk	11	1	9.6
Matapato North	58	5	8.6
<b>Total</b>	<b>114</b>	<b>9</b>	<b>7.9</b>

The prevalence of brucellosis was the highest (14%) in milk from cows from farms where the communal bull was used for breeding. Lower prevalence (3.12%) was found in milk from cattle where individual bull was used. The prevalence of brucellosis was higher (8.5%) in milk from cows where the herd size was above 100 than those below 100 (4.16%). Herd size was found to be insignificant ( $P \geq 0.05$ ) contributor of prevalence of brucellosis. The prevalence of brucellosis was found to be higher ( $p < 0.05$ ) in milk from cows where cattle were herded with other livestock species (8.7%) as compared to those of not herded with other livestock (4.5%).

### 3.3 Bacteria isolated from fermented cattle milk

There were 7 bacterial species isolated namely *Streptococcus* spp. (43.86%), *Lactobacillus* spp. (40.35%), *Klebsiella* spp. (15.79%), Coagulase Negative *Staphylococcus* (14.91%) *Pseudomonas* spp. (14.04%), *Staphylococcus aureus*(11.4%), *Salmonella typhi* (7.89%) and *Escherichia coli* (4.39%)-(Table 3).

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**Table 3: Proportion of bacteria isolated from fermented cattlemilk (n = 114)**

Isolate	Number of positive samples	Frequency (%)
<i>Streptococcus</i> spp.	50	43.86
<i>Lactobacillus</i> spp.	46	40.35
<i>Klebsiella</i> spp.	18	15.79
Coagulase Negative <i>Staphylococcus</i>	17	14.91
<i>Pseudomonas</i> spp.	16	14.04
<i>Staphylococcus aureus</i>	13	11.40
<i>Salmonella typhi</i>	9	7.89
<i>Escherichia coli</i>	5	4.39

### 3.4 Total coliform count isolated of locally collected fermented milk

The total coliform counts are shown in Table 4. The mean coliform count ranged from  $1.61 \times 10^1$  to  $5.84 \times 10^1$  CFU/ML. Milk from Dalalekutukward had higher ( $3.55 \times 10^1$ ) coliform counts than those from the other wards.

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**Table 4: Total coliform count isolated from locally collected fermented milk as categorized from each Ward.**

Location (Ward)	Number of Samples	Mean TCC(Cfu/ml)
Purko	30	$5.84 \times 10^1$
Iidamat	15	$1.61 \times 10^1$
Dalalekutuk	11	$3.55 \times 10^1$
Matapato North	58	$2.61 \times 10^1$

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**Key:** TCC;-Ttotal Ceoliform Ceount;;Cfu/ml; C-eoliform Eforming Uunit by milliliter

## 4. DISCUSSION

The current study evaluated the prevalence of brucellosis and other pathogenic bacteria isolated from fermented cattle milk consumed by households in Kajiado Central Sub-County. The study showed the prevalence of brucellosis was 7.9% and varied according to the wards of origin. This rate is lower than those found previously In Kenya, a previous study

done by Ndarathi & Waghela (4) in Kenya. They showed that seroprevalence of brucellosis in cattle from pastoral and agro-pastoral herd to range from 9.9-15%. Using the milk ring test, a study done by Chota et al. (20) in West Pokot Kenya, reported the cattle milk to have a prevalence of between 21.9% and 21.2%. Other studies have been reported lower values of brucellosis prevalence have been reported in other parts of Kenya with different climatic conditions (21). The present study demonstrated considerable levels of exposure to *Brucella* spp. in lactating herds, a finding that shows the public health risk posed by the disease in the study areas. A recent study in camels in Kenya showed the prevalence of brucellosis of 8% (5). The occurrence of brucellosis is influenced by various factors including tests used in diagnosis, livestock production systems, and variation of risk factors in different countries. In this study, the farmers reported that infertility, abortion, and reduced milk production was common amongst their cattle. These clinical signs have been associated with brucellosis in pastoral systems (22,23, 24).

In this study, the prevalence of brucellosis was found to be higher in farms using community bull than those using individual bull. Previous studies have shown that brucellosis was more prevalent on farms where communal bulls were used for breeding (25,26). Bull exchange for breeding and introduction of new animals to the herd are major risk factors for occurrence of brucellosis (27,28). The current study also showed that milk from households herding cattle and other livestock species had more brucellosis cases than those keeping cattle only. It is possible that herding of these animals together increases the chance of cross-species transmission of *Brucella* organisms (29).

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In the present study, *Streptococcus* spp., *Lactobacillus* spp., *Klebsiella* spp., Coagulase Negative Staphylococcus, *Pseudomonas* spp., *Staphylococcus aureus*, *Salmonella typhi* and *Escherichia coli* were isolated from the traditional fermented Maasai milk. Apart from *Lactobacillus* spp., which is a commensal in milk and facilitates the process of fermentation, the rest of the bacteria could be pathogenic. A similar range of pathogenic bacteria were observed in studies carried out in Egypt (Wigdan et al., 2006) and Sudan (Abdelgadir et al., 1998) and the authors attributed the presence of these bacteria to absence of hygienic presence of unhygienic conditions during milking and cleaning of utensils. The prevalence of *Streptococcus* spp. in the current study was close to that reported by Mathaara et al. (2004) (25%) in the same study area in Kenya. However, the prevalence of *Lactobacillus* spp. in the current study here was lower than that reported by the investigators in the same study (56.1%) (Mathaara et al., 2004).

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The findings of this work study indicate that the fermented milk harbored more coagulase negative Staphylococci as compared to *Staphylococcus aureus*. The occurrence of *Staphylococcus* spp. was high compared to a study those reported by others (30) in indigenous fermented milk from cattle in other parts of Kenya. Indigenous fermented milk often has high bacterial load due to low hygiene and sanitation practices during handling and processing (31,32). Other studies have reported the occurrence of low hygiene practices in African milk value chains (33, 34). The presence of *Staphylococcus* spp. in milk could also have originated from the use of milk from animals having clinical or subclinical mastitis. In Kajiado County, the prevalence of cattle mastitis is quite high and is caused by a wide spectrum of pathogens

including *Staphylococcus aureus*, *Streptococcus agalactiae*, *E.coli*, *Klebsiella* spp., *Pseudomonas* spp. (Ngotho et al., 2022, Mbidyo et al., 2022). Thus, it is possible that these bacteria could be found in fermented milk, if the latter is not well handled and processed.

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In previous studies, the occurrence of *E. coli* in milk has been associated with fecal contamination and this often leads to milk spoilage. In many African countries, indigenous fermented milk is processed, transported, and stored in reusable containers made from locally available materials such as wood fiber, clay pots, and plastic containers (35). According to Mathara et al. (36), sources of contaminations in *kulenaoto* traditional milk include starter cultures, the cow udder and the utensils used in preparation.

In the current study, the mean coliform count ranged from  $1.61 \times 10^1$  to  $5.84 \times 10^1$  CFU/ML which is close to that reported by Cissé et al. (37). From this study, the overall mean of the total coliforms was below the reference point of 100 cell/ml which could be the effect of fermentation process where the level of lactic acid bacteria increases the acidity of the milk that makes growth conditions of microorganisms other than lactic acid bacteria increasingly unfavorable.

## 5. CONCLUSION

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The overall prevalence of brucellosis in the study area was found to be close to that reported amongst other pastoralists in Kenya. Thus, in the study area, brucellosis could be affecting the animals significantly and risks getting transmitted to humans through traditional fermented milk. The latter is prepared from raw milk and thus the high risks not only for brucellosis but also for pathogenic bacteria such as *Streptococcus* spp., *Klebsiella* spp., *Staphylococcus* spp., *Pseudomonas* spp., *S. typhi* and *E. coli* which were observed in the study area. Public health education on milk hygiene and occurrences of milk-borne disease should be conducted in the study area with an aim of improving hygiene, milk preparation and modern breeding of cattle. Future studies on prevalence of brucellosis in humans in the study area should be done to determine the endemicity of the disease in the locality.

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## REFERENCES

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1. Muniya P, Bitek A, Osoro E, Pieracci EG, Muema J, Mwatondo A, Thumbi SM. Prioritization of zoonotic diseases in Kenya, 2015. *PLoS One* 11(8), 2016; e0161576.
2. McDermott J, Grace D, Zinsstag J. Economics of brucellosis impact and control in low-income countries, *Revue scientifique queet technique (International Office of Epizootics)*. 2013. 32(1): 249-261.

3. Arimi SM, Koroti E, Kang'ethe EK, Omoro AO, McDermott JJ. Risk of infection with *Brucella abortus* and *Escherichia coli* O157: H7 associated with marketing of unpasteurized milk in Kenya. *Acta Tropica* 2005; 96(1): 1-8.
4. Ndarathi CM Waghela S. Brucellosis in Maasai livestock in Kajiado district in Kenya. *Indian J. Anim.Sci.* 1991; 62: 156-163.
5. Aneja, R. P. *Technology of Indian milk products*. Dairy India Yearbook, 2002
6. Noor, M., Rotich, V., Kiarie, J. W., Cheruiyot, K., Kagira, J. M. Prevalence, risk factors associated with brucellosis and presence of pathogenic bacteria isolated from camel milk in Garissa County, Kenya. *South Asian Journal of Research in Microbiology*, 2020; 6(4), 42–52.
7. Fadaei, A. Bacteriological quality of raw cow milk in Shahrekord, Iran. *Veterinary World*, 2014, 7(4) 240-243.
8. Olatunji, E. A., Ahmed, I. Ijah, U. J. Evaluation of microbial qualities of skimmed milk (nono) in Nasarawa State, Nigeria. 2009, In *Proceeding of the 14th Annual Conf. of Ani. Sc. Asso. of Nig. (ASAN) LAUTECH O gbomoso*.
9. Bouazza, F., Hassikou, R., Ohmani, F., Hmamouchi, J., Ennadir, J., Qasmaoui, A., Khedid, K. Hygienic quality of raw milk at Sardi breed of sheep in Morocco. *African Journal of Microbiology Research*, 2012; 6(11), 2768-2772.
10. Claeys, W. L., Cardoen, S., Daube, G., De Block, J., Dewettinck, K., Dierick, K., Herman, L. Raw or heated cow milk consumption: Review of risks and benefits. *Food Control*, 2013; 31(1), 251-262.
11. Onyango, C. A., Gakuya, L. W., Matooke, F. M., Maina, J. M., Nyaberi, M. O., Makobe, M., & Mwaura, F. Preservative effect of various indigenous plants on fermented milk from Maasai community of Kajiado County. *Journal of Applied Biosciences* 2014, 73, 5935-5941.
12. Granet, H. M., Wetlesen, A., Mutukumira, A. N., Rukure, G, Narvhus, J. A. Occurrence of pathogenic bacteria in raw milk, cultured pasteurised milk and naturally soured milk produced at small-scale dairies in Zimbabwe. *Food Control*, 14(8), 539-544.
13. KNBS. Kenya Population and Housing Census Results. Kenya National Bureau of Statistics; 2019
14. Martin, J. A. Structural equation modeling: A guide for the perplexed. *Child Development*, 1987; 33-37
15. Megersa, B., Biffa, D., Abunna, F., Regassa, A., Godfroid, J., Skjerve, E. Sero epidemiological study of livestock brucellosis in a pastoral region. *Epidemiology & Infection* 2012; 140(5), 887-896.
16. Noriello S. Laboratory –acquired brucellosis. *Emerging infectious diseases*, 2004; 10: 1848-1850
17. Al-Mariri, A., Ramadan, L., Akel, R. Assessment of milk ring test and some serological tests in the detection of *Brucella melitensis* in Syrian female sheep. *Tropical Animal Health and Production*, 2011; 43(4), 865-870.
18. Ahern, H. *Microbiology: A Laboratory Experience*. Open SUNY Textbooks; 2018

19. Punch, J. D., Olson Jr, J. C. Comparison between standard methods procedure and a surface plate method for estimating psychrophilic bacteria in milk. *Journal of Milk and Food Technology*, 1964;27(2), 43-47.
20. Chota, A. C., Magwisha, H. B., Stella, B., Bunuma, E. K., Shirima, G. M., Mugambi, J. M., ... Gathogo, S. *Prevalence of brucellosis in livestock and incidences in humans in east Africa. African Crop Science Journal*, 2016;24(1),45.
21. Kang'ethe, E. K., Arimi, S. M., Omore, A. O., McDermott, J. J., Nduhiu, J. G., Macharia, J. K., Githua, A. *Testing for Antibodies to Brucella abortus in Milk from Consumers and Market Agents in Kenya Using Milk Ring Test and Enzyme Immunoassay. The Kenya Veterinarian*, 2016;27:18–21.
22. Singh, B. B., Dhand, N. K., Gill, J. P. S. Economic losses occurring due to brucellosis in Indian livestock populations. *Preventive veterinary medicine*, 2015;119(3-4), 211-215.
23. Makita, K., Fèvre, E. M., Waiswa, C., Eisler, M. C., Thrusfield, M., Welburn, S. C. Herd prevalence of bovine brucellosis and analysis of risk factors in cattle in urban and peri-urban areas of the Kampala economic zone, Uganda. *BMC veterinary research*, 2011;7(1), 1-8.
24. Abebe, G., and A. Yami. "Sheep and goat production handbook for Ethiopia." *Ethiopia Sheep and Goat Productivity Improvement programme (A Yami, RC Merkel, editors) Ethiopia Sheep and Goat Productivity Improvement programme (ESGPIP), Ethiopia* (2008): 71.
25. Bakhtullah, F. P., Shahid, M., Basit, A., Khan, M. A., Gul, S., Wazir, I., Raqeebullah, K. R. Sero-prevalence of brucellosis in cattle in southern area of Khyber Pakhtunkhwa, Pakistan. *Res. J. Vet. Pract*, 2014;2(4), 63-66.
26. Ebrahim, W. O. M. K., Elfadil, A. A. M., Elgadal, A. A. Seroprevalence and risk factors of anti-brucella antibodies in cattle in Khartoum State, the Sudan. *Journal of Advanced Veterinary and Animal Research*, 2016; 3(2), 134-144.
27. Alhaji, N. B., Wungak, Y. S., Bertu, W. J. Serological survey of bovine brucellosis in Fulani nomadic cattle breeds (*Bos indicus*) of North-central Nigeria: Potential risk factors and zoonotic implications. *ActaTropica*, 2016;153, 28-35.
28. Berhe, G., Belihu, K., Asfaw, Y. Seroepidemiological investigation of bovine brucellosis in the extensive cattle production system of Tigray region of Ethiopia. *International Journal of Applied Research in Veterinary Medicine*, 2007; 5(2), 65.
29. Verger, J. M., Garin-Bastuji, B., Grayon, M., Mahé, A. M. La brucellose bovine à Brucellamelitensis en France. In *Annales de recherches vétérinaires* 1989 (Vol. 20, No. 1, pp. 93-102).
30. Wambui, J., Njage, P. M. K., Tasara, T., Buys, E. M. Meta-analysis, and meta-regression indicate dynamic prevalence and moderators of foodborne pathogens in African indigenous fermented milk. *Microorganisms*, 2019;7(11), 563.
31. Paudyal, N., Anihouvi, V., Hounhouigan, J., Matsheka, M. I., Sekwati-Monang, B., Amoa-Awua, W., & Fang, W. (2017). Prevalence of foodborne pathogens in food from selected African countries—A meta-analysis. *International Journal of Food Microbiology*, 249, 35-43.

32. Manguiat, L. S., Fang, T. J. Microbiological quality of chicken-and pork-based street-vended foods from Taichung, Taiwan, and Laguna, Philippines. *Food Microbiology*, 2013;36(1), 57-62.
33. Odongo, N. O., Matofari, J. W., Lamuka, P. O., &Abey, K. A. (2017). Knowledge and practices of food hygiene and safety among camel milk handlers in the pastoral camel value chain in Kenya. *African Journal of Food, Agriculture, Nutrition and Development*, 17(1), 11803-11821
34. Muloi, D., Alarcon, P., Ombui, J., Ngeiywa, K. J., Abdullahi, B., Muinde, P., &Fèvre, E. M. (2018). Value chain analysis and sanitary risks of the camel milk system supplying Nairobi city, Kenya. *Preventive Veterinary Medicine*, 159, 203-210.
35. Nyambane, B., Thari, W. M., Wangoh, J, Njage, P. M. (2014). Lactic acid bacteria and yeasts involved in the fermentation of amabere amaruranu, a Kenyan fermented milk. *Food Science & Nutrition* (6), 692-699.
36. Mathara, J. M., Schillinger, U., Kutima, P. M., Mbugua, S. K., & Holzapfel, W. H. Isolation, identification, and characterisation of the dominant microorganisms of kulenaoto: the Maasai traditional fermented milk in Kenya. *International Journal of Food Microbiology*, 2004; 94(3), 269-278
37. Cissé, H., Muandze-Nzambe, J. U., Somda, N. S., Sawadogo, A., Drabo, S. M., Tapsoba, F., Savadogo, A. Assessment of safety and quality of fermented milk of camels, cows, and goats sold and consumed in five localities of Burkina Faso. *Veterinary World*, 2019;12(2), 295.