EVALUATION OF CHEMICAL COMPOSITION AND HYGIENIC QUALITY OF GOAT MILK IN KHARTOUM STATE, SUDAN

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Abstract
The present study was conducted to evaluate the chemical composition and bacterial load of goat milk samples collected in Khartoum State, Sudan during winter and summer season from dairy farm and individual households. The average of fat, solids not fat (SNF), protein and lactose content of goat milk samples were higher during winter season (5.11+0.2%, 9.3±0.07%, 3.6±0.03% and 5.0±0.04%, respectively). Similarly, the average of fat and SNF was higher in the milk samples collected from got dairy farms (5.4%±0.4% and 9.1±0.0%, respectively). The fat, lactose and acidity were significantly (P≤0.01) different in goat milk samples collected from different sources and the acidity was higher (0.15±0.0%) during summer. Moreover the acidity and density of milk samples collected from different sources and during different seasons showed high significant (P≤0.001) differences. Total bacterial count, coliform and psychrotrphic bacterial count of goat milk were higher during summer season (log_{10} 4.05±0.17 3.8, log_{10} 3.87±1.6 and log_{10} 2.06±1.1, respectively). Moreover, the microbiological load was high in the individual households (log_{10} 7.05±1.0, log_{10} 4.35±1.6 and log_{10} 1.9±1.1, respectively). The data from the different sources and during different seasons showed significant (P≤0.01) differences.

Keywords: Goat milk, season, dairy farm, households, composition, bacterial load

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1. INTRODUCTION

Goat milk and its products have a three-fold significance in human nutrition including feeding more starving and malnourished people and treating people affected with cow milk allergies (Haenlein, 2004). Goat milk has been used as a good alternative to human and bovine milk in various clinical conditions such as allergy, atop and inflammatory diseases (Jirillo *et al.*, 2010). Goat milk and the cheese made from it were venerated in ancient Egypt with some pharaohs supposedly having these foods placed among the other treasures in their banal tombs (Smith, 2006). Also, goat milk continued to play an important role in human nutrition in areas acknowledged as a cradle of modern civilization (Hatziminaoglou and Boyzglu, 2004). Thus, more people in the world drink milk from goats than from any other animal and this makes goats so popular in their ability to provide high quality food under diverse climate conditions and resilience to extreme environments (Morand-Fehr *et al.*, 2004). In addition, the short-chain fatty acids such as capric acid and caprylic acid, which present in goat milk, were found useful in therapies for patients suffering from malabsorption syndrome, metabolic disorders, problems with cholesterol, anemia, bone demineralization, and in infant malnutrition (Pop *et al.*, 2008). Goat milk in New Zealand, America is primarily produce for infant products, which have strict compositional requirements and it designed to match human breast milk so it must meet the normal growth need of the infants (Zaharia *et al.*, 2007). Goat milk is similar in basic composition to cow milk. On average, it contains about 12.6% of solids, 3.4% of protein, 3.8% of fat, 4.3% of lactose and 0.8% of minerals (Herian, 2008). According to Park *et al.* (2007), goat milk contains 3.56% fat. Mahmood and Usman (2010) investigated chemical composition of dairy goat indicating the lactose content ad density were 4.39±0.34% and 1.030±0.001

g/cm^3, respectively. Abd El Gadir and El Zubeir (2005) found that the averages milk constituents in crossbred (Saanen× Nubian) under Sudan conditions were 4.173±1.399% fat, 3.66±0.835% protein, 4.914±0.66% lactose, 0.733± 0.245% ash and 13.48±1.727% total solids.The milk composition (total protein 3.59± 0.03%, casein 2.87±0.025%, whey protein 0.72±0.007%, albumin 0.19±0.01 mg/1000g, β-lactoglobulin 0.27±0.003 mg/1000g, total solids 13.49±0.084% and solids not fat 9.11±0.049%) were higher during the early stage of lactation. Then were decreased (P>0.05) during the mid lactation stage (Mahmoud *et al.*, 2014).

Presence of high microbial load in goat milk can pose major economical loss for local farmers and smallholder dairies, as milk price is calculated based on the bacterial count, especially the pathogenic (Suguna *et al.*, 2011). Abdalla and El Zubeir (2007) concluded that the management practices influence the quality of goat milk. Kalhotka *et al.* (2013) investigated the microbial quality in raw goat milk and cheese and found that it contained a higher number of coliform and psychrotrophic microorganisms than the stated recommendations.

Previously, some of the pathogenic and spoilage bacteria such as *Listeria monocytogenes, Salmonella* sp, *Campylobacterspp, Staphylococcus aureus, Bacillus cereus, Escherichia coli*, and species of *Streptococcus, Staphylo-cocus* and *Micrococcus* have been isolated from fresh raw goat milk in various parts of the world (Kagkli *et al.*, 2007).

2. MATERIALS AND METHODS

This study was carried out in Khartoum State, Sudan. Twenty-five samples of raw goat milk were collected from the farms and 25raw goat milk samples from the individual house hold. The samples were collected during summer and winter seasons in order to study the chemical composition and hygienic quality of raw goat milk samples.

2.1 Collection of milk samples

The samples were collected into a clean dry bottles and transported in an ice-box (4-5^{o}C) to the laboratory of the department of Dairy Production, Faculty of Animal Production, University of Khartoum**.**

2.2 Chemical analysis

The chemical analysis of milk samples were determined by using milk analyzer Lactoscan 90 according to the manufacture instructions (Milkotronic LTD, Europe) to determine fat, protein, lactose, SNF and density of the milk samples. Acidity was determined by using the titration methods according to AOAC (1990).

2.3 Microbiological examination

The samples were inoculated for standard plate count, coliform count and psychrotrophic count. Sterilization, preparation of media and culturing methods were done according to the standard procedures (Barrow and Feltham, 1993).

Plate count agar no. 298 (Bio-mark laboratories) was used for enumeration of TBC and psychrotrophic counts. MacConkey agar no.779 (Bio-mark laboratories) was used for enumeration of coliform counts. Plates for enumeration of TBC and coliform were incubated at 32^{o}C for 48 hrs and 37^{o}C for 24 hrs, respectively.

Plates for enumeration of psychrotrophic counts were incubated at 7^{o}C for ten days (Ballou *et al* 1995). Developed colonies were counted using manual colony counter. The plates counting 25-250 colonies were selected as described by Houghtby *et al*. (1992). The number reciprocal of the dilution factor was recorded as cfu $^{-1}$.

2.4 Statistical analysis

The collected data were analyzed by factorial design using SPSS (Statistical Packages for Social Sciences) computer program.

Table 1: Comparison of chemical composition of goat milk samples collected during winter and summer seasons in Khartoum State

Chemical composition	Measurements	Winter	Summer	Total
Fat (%)	**Means +SE**	5.11±0.2	4.90±0.1	5.0±0.2
Solid not fat (%)	**Means +SE**	9.3± 0.07	9.0±0.07	9.15±0.0
Density (g/cm^3)	**Means +SE**	1.033±0.0	1.032±0.0	1.033±0.0
Protein (%)	**Means +SE**	3.6±0.03	3.5±0.02	4.5±0.02
Lactose (%)	**Means +SE**	5.0±0.04	4.8±0.04	4.9±0.4
Acidity (%)	**Means +SE**	0.14±0.00	0.15±0.0	0.15±0.0

Table 2: Comparison of chemical composition of goat milk samples collected from Sources in Khartoum State

Chemical composition	Measurements	Farms	Individual households	Total
Fat (%)	**Means +SD**	5.4±0.4	4.5±0.8	5.1±0.6
Solid not fat (%)	**Means +SD**	9.1±0.07	9.0±0.07	9.05±0.0
Density (g/cm^3)	**Means +SD**	1.033±0.0	1.032±0.0	1.033±0.0
Protein (%)	**Means +SD**	3.5±0.03	3.6±0.02	3.5±0.0
Lactose (%)	**Means +SD**	4.8±0.04	4.9±0.04	4.9±0.0
Acidity (%)	**Means +SD**	0.14±0.0	0.15±0.0	0.15±0.0

3. RESULTS AND DISCUSSION

The fat content of goat milk samples during different season revealed no variations (Table 1 and Table 3). However from different sources it revealed significant differences (Table 2 and Table 3). The obtained values were higher (3.83±0.02) than those reported by Jadalla, 2012; Purnomo and Muslimin, 2012 and Abdel Rahman *et al.*, 2013). Also the values were less than those reported by Blaga (2009) who found 3.95±0.07, 5.21±0.04 during summer and winter, respectively. The recent mean value (3.5%) was similarly higher than Strzałkowska *et al.* (2009); Mahmood and Usman (2010) and El Zubeir *et al.* (2012). Also it was higher than the 3.13% reported in White Shorthaired goats in Czech (Dračková *et al.*, 2008), 3.62-3.86% in Turkish Saanen (Konyali *et al.*, 2010), 3.04% in Polish White Improved goats in Poland (Olechnowicz and Sobek, 2008), 2.76 and 4.38% in Alpine and Nubian goats, respectively in the USA (Soryal *et al.*, 2005).

Solids not fat of goat milk samples collected from different sources showed non-significant variation (Table 2 and Table 3). However during different season highly significant variations were obtained (Table 1 and Table 3). The present results were higher (8.16±0.42%) than those reported by Wasiksiri *et al.* (2010). The results agreed with Blaga (2009) who found 8.95±0.05% during summer and 8.95±0.05 during winter season and Mahmoud *et al.* (2014) who found 9.11±0.049%) for Damascus goats raised in Sudan. The obtained values were near to those reported by Abdel Rahman *et al.* (2013). Significant variations were found in the density of goat milk from both sources and during the different seasons. The results were similar to Strzałkowska *et al.* (2009) in Saaneen lactating goat. Moreover Blaga (2009) found 1.029±0.01% and 1.033±0.01 during winter and summer, respectively.

Protein of goat milk samples collected from different sources revealed non significant differences (Table 2 and Table 3), while during different seasons significant differences were found (Table 1 and Table 3).

Table 3: Comparison of chemical composition of goat milk samples collected during winter and summer seasons in Khartoum State

Measurements	Sources		Seasons		Sources × seasons	
	Mean square	Significant level	Mean square	Significant level	Mean Square	Significant level
Fat (%)	8.51	0.004**	0.43	0.49 NS	1.34	0.23 NS
Solid not fat (%)	0.29	0.14 NS	1.49	0.002***	0.005	0.84 NS
Density (g/cm^3)	2.08×10^5	0.01**	1.67×10^5	0.01**	4.55×10^7	0.66 NS
Protein (%)	0.41	0.15 NS	0.22	0.002**	1.49×10^6	0.99 NS
Lactose (%)	0.196	0.035 **	0.404	0.003**	0.004	0.748 NS
Acidity (%)	0.003	0.001***	0.004	0.001***	0.004	0.001***

NS = non significant at P≥0.05
** = significant at P≤0.01
*** = highly significant at P≤0.001

Table 4: Variations of hygienic quality of goat milk samples collected during winter and summer seasons in Khartoum State

Bacterial loads	Seasons	Mean ± SE
Log total bacterial count	Winter	3.52±1.8
	Summer	4.05±0.17
	Total	3.78±0.9
Log coliform count	Winter	2.32±1.2
	Summer	3.87±1.6
	Total	3.09±1.4
Log psychrotrophic count	Winter	1.31±1.3
	Summer	2.06±1.1
	Total	2.01±1.2

El Zubeir *et al.* (2012) reported that the average milk protein values were 3.78±0.02% during summer and 4.42±0.03% during winter. Moreover, the value was lower than that reported by Blaga (2009). Whereas, it was near the value that reached by Mahmood and Usman (2010) and Mahmoud *et al.* (2014). Variation in protein might be due to breed difference, health status of the udder and stage of lactation (Mahmood and Usman, 2010). The results were lower (4.72%) than that found by Purnomo and Muslimi (2012), and Abdel Rahman *et al.* (2013). Moreover the protein content was 3.01% in Polish White Improved goats in Poland (Olechnowicz and Sobek, 2008) and 3.15% in Swedish Landrace goats in Sweden (Högberg, 2011).The lactose content of goat milk samples collected from different sources revealed significant differences (Table 2 and Table 3), moreover, the variation during different seasons revealed highly significant variations (Table 1 and Table 3). Similarly Blaga (2009) reported the lactose was higher (4.39±0.03%) during summer and lower (4.30±0.02%) during winter. The values were near to those reported by Purnomo and Muslimin (2012) and Abdel Rahman *et al.* (2013). Similarly, it was close to that reported in Polish White Improved goats in Poland (Olechnowicz and Sobek, 2008). However, it was lower than that reported in White Short-haired goats in Czech (Dračková *et al.*, 2008), and in Bianca Monticellana goat in Italy (Palocci and Tripaldi, 2011), in Swedish Landrace in Sweden (Högberg, 2011).

When titratable acidity of goat milk samples were compared highly significant variations were found (Table 1, Table 2 and Table 3).

Higher average acidity (0.231% and 0.203%) was reported by Abdalla and El Zubeir (2007) and Abd El Gadir and El Zubeir (2005). in Sudan. The results were lower than that reported by Purnomo and Muslimin (2012). Acidity of goat milk sample collected from different sources and during different seasons showed highly significant, which might be due to the high temperature during the summer season (Table 1 and Table 3). Wasiksiri *et al.* (2010) and Mahmood and Usman (2010) reported similar values 0.16±0.01% and 14±0.03%, respectively.Total bacteria count in raw goat milk samples revealed high significant differences high during summer season (Table 4 and Table 6). Similarly Suguna *et al.* (2011) found that TBC was log 4.2 in goat milk samples. The milk samples also revealed significant differences (high in individual house hold) as shown in Table 5. This might be because most farms who were small farming systems and do not give adequate feeding which might negatively affect the milk quality. Abdalla and El Zubeir (2007) reported that the influence of housing system on milk quality revealed an increase in the number of bacterial colony especially in the random designed housing. Some farms encountered bacterial contamination because of unsuitable processes during milking or might have been influenced by extrinsic factors such as level of hygienic condition during handling of milk, season and geographical location of the dairy farm (Millogo *et al.*, 2010).

Coliform of milk samples collected during different seasons revealed high significant differences (higher during summer) as shown in Table 4 and Table 6. Abdalla and El Zubeir (2007) reported higher average of the coliform count ($636\times 10^5\pm$ 16.6 cfu/ml).

The results was higher than those reported by Oliveiraa *et al.* (2011) who found coliform was 1.9×106 in bulk tank goat milk samples. Coliform of milk samples collected from sources revealed highly significant variation, this indicate a problem of dirty goats being milked and unclean udder, unsanitary milking practices, or milk contamination in the container (Wasiksiri *et al.*, 2010).

Table 5: Comparison of hygienic quality of goat milk samples collected from different sources in Khartoum State

Bacterial counts	Sources	Mean± SE
Log total bacterial count	Farms	6.52±1.4
	Individual household	7.05±1.0
	Total	6.78±1.2
Log coliform count	Farms	3.08±1.3
	Individual house hold	4.35±1.6
	Total	4.01±1.5
Log psychrotrophic count	Farms	1.4±1.3
	Individual house hold	1.90±1.1
	Total	1.8±1.2

Table 6: Comparison of hygienic quality of goat milk samples collected from different production systems and seasons in Khartoum State using ANOVA analysis

Measurements	Sources		Seasons		Sources × Seasons	
	Mean square	Significant level	Mean square	Significant level	Mean square	Significant level
Log total bacterial count	25.04	0.001***	0.747	0.001***	0.08	0.75^{NS}
Log coliform count	10.7	0.006**	0.443	0.072*	0.34	0.001***
Log psychrotrophic count	0.37^{NS}	0.001***	0.421	0.075^{NS}	0.03	0.43^{NS}

NS = non significant at P≥0.05 * = significant at P≤0.001 ** = significant at P≤0.05.

Occurrence of psychrotrophic bacteria in some milk samples highlights the tendency of these bacteria to grow and multiply once stored at low temperature. Psychrotrophic bacteria in milk samples during seasons revealed significant differences and it was higher during winter season (Table 4 and Table 6). This might be due to fact that farmers fail to store the milk under cooling conditions after milking for long duration of time, so rapid contamination might occur by this bacterium (Kalhotka *et al.*, 2013).

4. CONCLUSIONS

Generally, good quality milk was found in the dairy farms compared to the individual households. Moreover high bacterial loads were found in goat milk samples obtained during summer. Hence, the study suggested that more efforts are needed to improve milk hygiene and quality by raising awareness among the small producers

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