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Cheese Production from Camel Milk Using Lemon Juice as a Coagulant

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Abstract: Camel milk is the common food for pastoral society and rich source of nutrients with therapeutic value. Processing of camel milk can increase the coagulation of protein for better sensory properties and handling. Milk processing can improve the nutritional properties, increase the digestibility of macromolecules and make it safe from harmful microbes. Cheese formation from cattle milk is an easy task, however, not in case of camel milk. Various products including citric acid and lactic acid used to facilitate cheese formation from camel milk. This study was designed to evaluate the coagulating effects of lemon juice for making cheese from camel milk. Soft cheese was made from 8 Liter camel milk using different volumes of lemon juice extract (150ml, 200ml, 250ml, 300ml, 350ml, 400ml, 450ml, and 500ml) after 24 h storage at ambient temperature, and each sample used 1Liter camel milk for each volume, and then samples (T1, T2, T3, T4, T5, T6, T7, and T8) were analyzed for their percentage of yield, chemical composition, and sensory characteristics. The result has shown that maximum ash and lactose content were observed in T1 (product) (2.7%, 17.36cal), and, moisture and protein content in sample T8 (60.51%, 12.74%) while, energy content in T4 (product) (227.5cal) and fat content in T6 (product) (14.69%) respectively. Significant ($P<0.05$) increased yield of cheese was observed in T8 during more lemon juice addition. Moreover, the cheese developed was characterized with higher energy, fat, moisture, protein contents and high scores of softness property, color, flavor, and overall acceptability by increasing the lemon juice addition. In conclusion, the addition of lemon juice to camel milk could offer an economically suitable means for producing coagulated milk cheese.

Keywords: Camel milk, Carbohydrate, Cheese, Lemon, Protein Proximate, Sensory.

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1.Introduction

Camels are one of the oldest domesticate animals in the semi arid and arid areas of the world. Due to nutritional values camel milk is also called "white gold of the desert" (Fukuda, 2013). Dromedary camels (*Camelus dromedarius*) produce milk of high nutritional value (Al Haj and Al Kanhal, 2010; Khalesi et al., 2017), which can be kept safe for a longer period of time under hot environmental conditions (Khan and Iqbal, 2001; Khalesi et al., 2017; Konuspayeva et al., 2009). Sales of milk, meat, hides, and transport services provided by camel represents a saving instrument for pastoral community (Berhe et al., 2017). Apart from its nutritional and financial values, camel milk is used as a traditional medicine in the treatment of a wide range of diseases and problems (Dubey et al., 2016; Sharma. and Singh, 2014).

For a long period of time, camel milk has been drunk as raw and sometimes with coffee and tea in many parts of Somali region, Ethiopia. There was limited trend in development of camel milk processing practices. Consequently, pastoralists couldn't be benefited from variety of milk products such as cheese, yoghurt and butter. Cheese is a fermented milk product with high levels of milk fat and low levels of water, however, lower levels of water and lactose. Cheese is made from the curds produced when milk is coagulated (Bintsis and Papademas, 2017; Fox and Guinee, 2013; Sánchez-

Muñoz et al., 2017). It is an easy process if the milk proteins are precipitated and separate from the way. In cattle milk coagulation is faster since the protein casin micelles are very smaller in size and results coagulation within a short period of time (Bintsis and Papademas, 2017), However, camel milk lacks this behavior due to lower concentration of k-casein, causing difficulty in achieving coagulation (Hailu et al., 2018; Konuspayeva et al., 2017).

People have used different coagulant for the formation of curd for many years. The chemical rennin enzyme, which is extracted from the calf stomach of young ruminants, such as cows, goats, and sheep has been used to coagulate milk and to form curds and whey which are essential in the cheese making process. Many other locally available vegetables have been reported for their potentials to coagulate camel milk. Of these, *Cynara carduncculus* (García et al., 2014), *Calotropis procera*, also known as Sodom apple (Akinloye and Adewumi, 2014), and crude extract of ginger (*Zingiber officinale*) (Hailu et al., 2014) are notable examples.

Citric acid from different fruit sources such as lemon, lime and orange juice has also been tasted for coagulating potential on goat and cow milk (Adetunji et al., 2007). When milk becomes too acidic or goes sour like by adding lemon juice, negative charges on casein groupings may become neutralized and eventually large enough clumps may be formed to produce curdled milk (Emma, 2009). However, previously there was no work done on the coagulation effect of lemon juice for camel cheese processing. Therefore, this study aimed to evaluate the coagulating effects of lemon juice for cheese making using camel milk.

2. Materials and Methods

2.1. Experimental Conditions and Materials

The study was conducted from January, 2016 to January, 2017 in Animal Nutrition Laboratory at Jigjiga University (ANL-JJU), Ethiopia. Suitable fresh raw camel milk was purchased from three different sites in Kebribeyah district of Ethiopian Somali Regional State (ESRS). Milk samples were quickly transported to ANL – JJU under cold chain condition and used for experimental trial within 24 hours. The sample lemon fruits were purchased from local markets in Jigjiga town, Ethiopia. Lemon juice extract was prepared by cutting it into 8 medium size pieces and individually squeezing them into a clean bowl to harvest the juice.

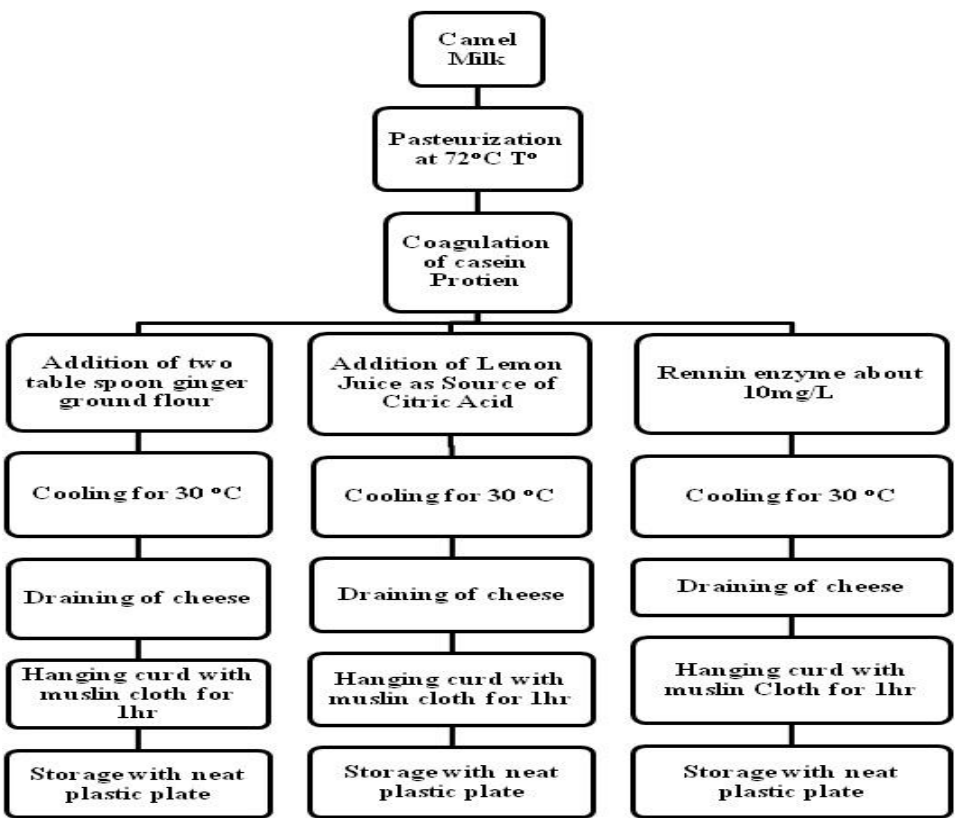

Fig. 1. Flaw chart of cheese processing using lemon juice, rennin enzyme, and ginger spice.

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Fig. 2. Processing steps to develop cheese from camel milk using lemon juice as coagulant.

The extracted juice was sieved, measured with measuring cylinder and thoroughly mixed with equal volume of clean water giving a total of stock solution. Liquid camel Chymosin Rennet (Chy-Max® M, Christian Hansen, Denmark) with activity of 1000 IMCU (International Milk Coagulating Unit)/ml and ginger spice powder were also purchased from local retailers.

A completely randomized trial design was used to evaluate the effect of different volumes (150, 200, 250, 300, 350, 400, 450 and 500 ml) of lemon juice extract samples treatments (T1 – T8) on the macro-elements, sensory characteristics and yield of cheese produced from 1 L fresh raw camel milk. Herein, treated raw camel milk (1 L) was used as a negative control (C1) whereas 0.15 g Rennet enzyme (0.1 ml/L) and 28.3 g/L Ginger spice were used for manufacturing of soft unripend cheese as positive controls (C2 and C3). The experimental trial was run three times on estimated mean values for independent variables (different volumes of lemon juice supplement and control treatments applied to camel milk) and dependent variables (yield, nutritional composition and sensory characteristics of cheese products). The design was verified using the following model described in equation 1:

$$Yij = \mu + Ti + \varepsilon i \quad [1]$$

Where: μ= population means, Ti= samples treatment level, and εi= random error.

2.2. Cheese Preparation

Fresh camel milk (22 liters) sample was divided in to 11 equal portions (i.e. 2 litters each) and 1 L of each portion was poured on to eleven labeled (C1, T1 – T8, C2 and C3) clean plastic dishes. Each portion of the camel milk was boiled in a separate metal pot over an electric cooker in open air to bring the temperature to 72 °C. Then, experimental (T1 =150ml lemon juice mixed with 1L camel milk to T8 = 500 ml lemon juice mixed with 1L camel milk by 50 ml lemon juice increments) and control (0.15 g Rennet enzyme (C2) and (28.3 g) Ginger spice (C3)) treatments were added on to hot camel milk preparations bearing their corresponding labels. With intermittent stirring, heating continued until milk preparations started to boil. Heating of the curd was maintained at boiling point for about 10 minutes until full coagulation and visible separation of cheese from whey. Loose curd products were sieved (15 min), over a measuring cylinder, to facilitate whey drainage and molding of cheese products into solid shape (Fig. 1).

2.3. Cheese Yield and Acidity Measurement

The quantity of cheese produced from each experimental as shown in (Fig. 2) and control treatment preparation was weighed on an electric scale (Akinloye and Adewumi, 2014). Acidity of cheese products was measured according to the titrimetric method (Method No. 920.124 of AOAC, 2000).

2.4. Proximate Analysis of Camel Cheese

Proximate analyses was carried out on raw camel milk samples as well as cheese produced from negative (C1) and positive (C2 and C3) control and experimental lemon juice treatment (T1 – T 8) preparation in all 3 trial rounds. Moisture, Total Solid (TS) and Ash contents of cheese samples were determined using standard food analysis methods (AOAC, 1990). Total nitrogen (TN) was estimated by Kjeldahl method (Method No. 20B, IDF 1986); crude protein was calculated as TN × 6.38; and Fat content was measured by Gerber method (Marshall, 1992). Energy content of cheese products was calculated by multiplying the protein, fat and carbohydrate contents with energy conversion factors (Protein = 4cal, fat = 9cal and carbohydrate = 4cal). Likewise, lactose content of camel milk was estimated by subtracting the sum of moisture, fat, protein and ash contents from 100 %.

2.5. Sensory Characteristics of Camel Cheese

Sensory analysis of camel milk cheese was conducted FSNL – JJU employing a total of 20 panelists, 10 males and 10 females recruited based on knowledge of sensory analysis from staff and 3rd years students of Department of Food Science and Nutrition (FScN) at JJU. Cheese produced from different treatment groups (C1 - C3 and T1 – T8) during all 3 experimental runs were evaluated for sensory characteristics shortly after processing. Cheese products,sliced with a clean sharp knife, were arranged according to their source. Panelists following standard sensory evaluation procedures were allowed to taste slices from each cheese product and record their individual assessments. Sensory evaluation was performed on the basis of taste, color, flavor, sourness and acceptability of cheese products based on hedonic scale (9- extremely like, 5-neither like nor dislike, 1- extremely dislike) as previously described (Piggott., 1984; Stone and Sidel, 1985).

2.6. Statistical Analysis

The triplicate trial run data was summarized and analyzed using SPSS 20 software. Analysis of Variance (ANOVA), Least Significance Difference (LSD) or DMRT tests were used to compare variations in means values of dependent variables (yield and acidity; Proximate Composition and sensory qualities of cheese products**)** relative to milk treatment groups (C1-C4 and T1 – T8) according to Gomez and Gomez, (1984). Variations at P < 0.05 (2 sided) level were considered significant.

3. Results and Discussion

3.1. Chemical Composition of Camel Milk

Compared to literature references, camel milk samples in this study showed lower fat content (3.23 %) than other major domestic animal species. In contrast, camel milk had higher moisture, protein and TS content than milk of buffalo, goat and sheep, respectively (Table 1).

3.2. Camel Cheese Yield and Acidity

Currently, both the acidity and yield of camel cheese products increased ($p < 0.05$) linearly with increasing experimental lemon juice treatment volumes (Table 2). Average cheese yield (%) was comparably low in negative control (7.95) and in 150 ml (9.86) to 200 ml (9.97) lemon juice treatments.

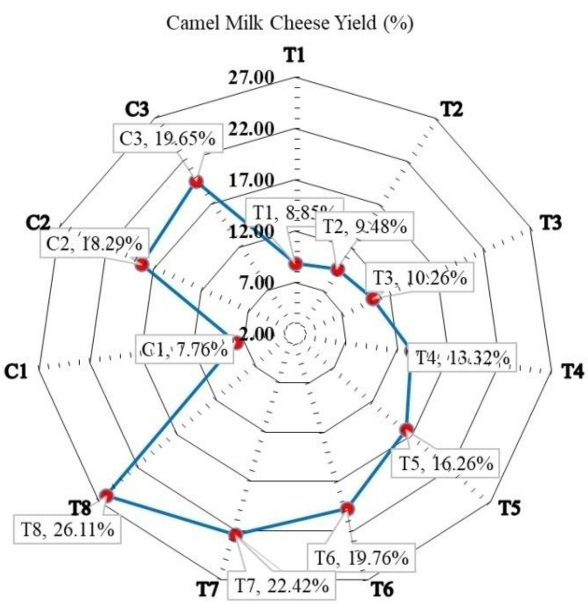

Fig. 3. Radar chart of cheese yield using different volume of lemon juice as coagulant.

Table 1. Chemical Composition of raw milk of different animals

Sample	Acidity	Energy	Lactose	Ash	Fat	Moisture	Protein	TS	References
	%	(cal/100g)		%					
Camel milk	0.193	66.2	3.99	0.93	3.23	88.0	3.05	12.20	**
Cow milk	ND	69.0	4.60	0.70	3.9	87.8	3.2 0	12.30	Rashmi et al. (2013)
Goat milk	ND	70.0	3.88	0.80	4.06	87.7	2.92	12.33	El-Alamy et al. (1990)
Sheep milk	ND	ND	3.70	0.90	7.62	89.7	6.21	10.33	Posati and Orr (1976)
Buffalo milk	ND	105.1	5.02	0.80	7.52	82.3	4.02	17.65	Ghada (2005)

** Values are determined from raw camel milk in this experiment. ND= Not detected, TS= total solid content.

Table 2. Acidity, yield and mass of cheese of the camel milk using lemon juice as coagulant

Treatment	Acidity (%)	Yield (%)	Mass of cheese (g/L)
T1 (1L camel milk + 150ml lemon juice)	0.45±0.01[h]	9.86±0.03[i]	196.7
T2 (1L camel milk + 200ml lemon juice)	0.50±0.01[g]	9.97±0.02[i]	199.6
T3 (1L camel milk +250ml lemon juice)	0.53±0.01[f]	10.32±0.01[h]	206.4
T4 (1L camel milk + 300ml lemon juice)	0.59±0.02[e]	10.54±0.02[g]	210.8
T5 (1L camel milk + 350ml lemon juice)	0.62±0.01[d]	15.15±0.03[e]	303
T6 (1L camel milk + 400ml lemon juice)	0.66±0.01[c]	18.52±0.01[c]	370
T7 (1L camel milk + 450ml lemon juice)	0.70±0.01[b]	23.17±0.01[b]	467.1
T8 (1L camel milk + 500ml lemon juice)	0.73±0.01[a]	25.56±0.03[a]	500
C1 (1L camel milk alone)	0.35±0.01[j]	7.95±0.06[j]	178
C2 (1L camel milk + 0.15g Rennet enzyme)	0.34±0.01[j]	10.94±0.01[f]	230
C3 (1L camel milk + 2 table spoon Ginger spice)	0.39±0.02[i]	11.73±0.23[d]	450

*Values are in Means of a triplicate data ± STDEV. Means (n) with in a column with the same letter are not significantly different (P>0.05). T1,-----T8 =Samples 1 up to 8 indicating lemon juice extract of different volume from 150mL up to 500mL by 50 ml volume increment. C1=camel milk alone, C2=Camel milk with Rennin enzyme, and C3= camel milk with Ginger spice.

Milk preparations with ≥ 350 ml lemon juice treatments showed higher cheese yield (T5/ 15.15 – T8/ 25.56 %) than both positive controls (Rennet enzyme (10.94 %) and Ginger spice (11.73 %)). Meanwhile, acidity of cheese products from negative (0.35 %) and positive (Rennet enzyme (0.34 %) and Ginger spice (0.39 %)) control groups was lower than that of progressively increasing values experimental lemon juice treatment volumes which (T1 (0.45 %) to T8 (0.73 %)) (Fig.3). These findings indicate that addition of higher lemon juice volumes can increase the acidity and improve the coagulation of camel milk. Similarly Seth and Bajwa (2015) have reported the highest recovery of fat and protein when milk treated with acetic and lactic acid.

3.3. Proximate Composition of Camel Cheese Products

Overall, increasing volumes of lemon juice supplementation increased the moisture, fat, protein contents and energy of camel milk soft cheese products whereas components such as ash and lactose contents showed the inverse progressively decreasing trend (Table 3). Specifically, moisture content of the cheese increased with increasing lemon juice supplementation being highest in T8 (60.5 %) followed by T7-T6 (59.4 – 59.5 %) preparations. Moisture content was lowest in negative control preparation (58.2 %). Others have similarly observed that increasing acidity elevated the moisture content of cheese products (Seth and Bajwa, 2015; Dagostin et al., 2013).

Table 3. Proximate composition of cheese made from camel milk using lemon juice as coagulant (Mean, %).

Treatment	Energy (cal/100g)	Lactose (cal/100g)	Ash (%)	Fat (%)	Moist (%)	Protein (%)	TS (%)
T1	217.6±0.32[e]	17.36±0.04[b]	2.70±0.01[d]	12.66±0.05[e]	58.72±0.01[e]	8.56±0.04[j]	41.28±0.02[ef]
T2	222.4±0.15[c]	15.12±0.06[c]	2.68±0.01[e]	13.62±0.03[d]	58.75±0.01[de]	9.84±0.04[h]	41.25±0.02[ef]
T3	222.6±0.17[c]	14.07±0.03[d]	2.66±0.01[f]	13.66±0.02[c]	58.77±0.01[de]	10.84±0.03[f]	41.23±0.58[cd]
T4	227.5±0.04[a]	12.06±0.05[e]	2.62±0.01[g]	14.67±0.02[ab]	58.83±0.02[de]	11.83±0.02[e]	41.17±0.79[ed]
T5	227.2±0.06[a]	11.88±0.08[e]	2.60±0.01[h]	14.68±0.01[ab]	58.95±0.01[d]	11.89±0.05[d]	41.05±0.04[cb]
T6	225±0.11[b]	11.03±0.05[f]	2.58±0.01[i]	14.69±0.02[a]	59.54±0.04[b]	12.15±0.03[c]	40.46±0.04[cb]
T7	225.4±1.65[b]	11.01±0.45[f]	2.58±0.01[i]	14.66±0.02[ab]	59.39±0.43[bc]	12.37±0.02[b]	40.61±0.46[b]
T8	221±0.20[d]	9.56±0.04[g]	2.55±0.01[j]	14.64±0.04[b]	60.51±0.04 [a]	12.74±0.04[a]	39.49±0.11[a]
C1	213.3±0.08[f]	21.66±0.03[a]	2.81±0.01[a]	10.68±0.01[g]	58.22±0.02 [f]	7.63±0.01[k]	41.78±0.04[f]
C2	212.7±0.20[f]	17.27±0.05[b]	2.75 ±0.01[c]	11.71±0.01[f]	58.72±0.03[e]	9.55±0.04[i]	41.28±0.07[ef]
C3	205.5±0.04[g]	17.12±0.02[b]	2.77 ±0.01[b]	10.71±0.02[g]	59.24±0.02[c]	10.16±0.02[g]	40.76±0.27[f]

Values are in Means of a triplicate data ± STDEV. Means (n) with in a column with the same letter are not significantly different (P>0.05). T1,-----T8 =Samples 1 up to 8 indicating lemon juice extract of different volume from 150mL up to 500mL by 50 mL volume increment. C1=camel milk alone, C2=Camel milk with Rennin enzyme, C3= camel milk with Ginger spice, and TS= total solid content.

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The fat content of cheese products was comparably high (14.6 - 14.7 %) in camel milk supplemented with 300 ml (T4) - 500 ml (T8) of lemon juice. Furthermore, even lower volumes (T3=250 – T1=150 ml) of lemon juice supplementation exhibited higher ($p < 0.050$) fat content than negative and Ginger spice treated (10.7 %) as well as Rennin treated (11.7 %) control. Raw camel milk has smaller fat globules which coalesce lesser and decrease cheese fat content (Stahl et al., 2006). In agreement, adding acidulants such as acetic acid and lactic acid to milk was indicated to increase fat content of cheese (Seth and Bajwa, 2015). In contrast, Keceli et al. (2017) reported that pre-acidification of cheese with citric acid had no significant difference in cheese fat content from controls.

Increasing the volume of lemon juice added to camel milk preparations was associated with a linearly rising ($p < 0.050$) protein content of cheese products (T1=8.6 % to T8 = 12.7 %). Cheese protein content was lowest in negative controls (7.6 %) whereas ginger spice (10.2 %) and renin (9.55 %) positive controls had comparable averages with experimental treatment of lemon juice volumes of <T3 (<250 ml). Similar results were also reported by Seth and Bajwa (2015). This trend could be due to the effect of citric acid from lemon juice to bring together casein proteins in to large globules. Energy content of cheese was generally lower in controls (negative and positive) than all lemon juice treated camel milk preparations. In the latter, energy content was higher in 300 ml (T4) to 350 ml (T5) lemon juice treatment volumes but decreased beyond (below and above) these volumes. Given the indirect estimation of energy content, this trend could reflect effect of parallel changes in protein and fat content.

Higher cheese ash content was observed in negative (2.8 %) and positive (Ginger spice (2.8 %) and Rennet (2.75 %) control followed by progressively decreasing ($p < 0.05$) levels in increasing experimental lemon treatment volume groups (T1 (2.7 %) to T8 (2.55 %)). Increasing acidity from lemon juice (fresh citric acid content 48 g/L) could cause dissociation or dissolving of more minerals in casein protein leading to lower levels in cheese products. In agreement, Keceli et al. (2017) have shown that cheese pre-acidified by citric acid had lower ash and calcium contents. Likewise, cheese lactose content calculated as difference of the sum of moisture, fat, protein and ash content from 100 % was negatively associated with increasing lemon juice supplementation volumes. This probably reflects an indirect consequence of simultaneously increasing moisture, fat and protein contents.

3.4. Sensory Acceptability of Camel Milk Cheese

The result for sensory acceptability of experimental cheese products was reported based on 9-Point Hedonic Scale (9 - extremely like to 1-extremely dislike). Overall, higher lemon juice treatment volumes increased average sensory acceptability score of camel cheese products as compared to control (C1, C2, C3 and C4) sample products ($p > 0.050$). Specifically, higher volumes of lemon juice progressively increased average sensory softness score of experimental cheese products. Furthermore experimental treatment preparations had higher average softness score than control preparations.

Table 4. Sensory Analysis for Camel Milk Cheese

Treatment	Softness	Sourness	Color	Odor	Flavor	Appearance	OAA
T1	$2.35±0.75^{j}$	$2.50±0.77^{g}$	$1.90±0.73^{h}$	$2.01±0.89^{h}$	$2.35±0.97^{h}$	$2.25±0.65^{gh}$	$2.25±0.87^{h}$
T2	$2.45±0.83^{i}$	$2.60±1.11^{f}$	$2.00±0.64^{g}$	$2.10±0.75^{g}$	$2.50±0.76^{g}$	$2.25±0.79^{gh}$	$2.29±0.79^{h}$
T3	$2.59±0.78^{h}$	$2.74±1.21^{e}$	$2.06±0.73^{f}$	$2.11±0.76^{g}$	$2.67±0.91^{f}$	$2.28±0.84^{g}$	$2.33±0.91^{g}$
T4	$2.70±0.69^{g}$	$2.75±0.91^{e}$	$2.25±0.75^{e}$	$2.15±0.76^{g}$	$2.75±0.64^{e}$	$2.30±0.57^{g}$	$2.40±0.83^{f}$
T5	$3.27±0.68^{d}$	$2.78±0.74^{e}$	$2.38±0.68^{d}$	$2.25±0.92^{f}$	$2.80±0.77^{d}$	$2.35±0.63^{f}$	$2.75±0.67^{e}$
T6	$3.35±0.76^{c}$	$2.85±0.99^{d}$	$2.45±0.49^{c}$	$2.25±1.16^{f}$	$2.85±1.09^{c}$	$2.38±0.56^{f}$	$2.90±0.72^{d}$
T7	$3.43±0.51^{b}$	$2.91±0.96^{c}$	$2.58±0.81^{b}$	$2.76±0.89^{e}$	$3.21±0.85^{b}$	$3.19±0.75^{c}$	$3.00±0.71^{d}$
T8	$3.70±1.11^{a}$	$3.75±1.12^{a}$	$2.80±0.98^{a}$	$3.65±1.08^{b}$	$3.35±0.81^{a}$	$3.80±0.83^{a}$	$3.85±1.17^{a}$
C1	$2.85±1.73^{e}$	$2.25±1.59^{i}$	$2.05±0.94^{f}$	$2.03±1.47^{h}$	$2.20±1.19^{i}$	$2.15±1.31^{h}$	$2.21±1.50^{h}$
C2	$2.75±1.41^{f}$	$2.54±1.14^{b}$	$2.05±0.76^{f}$	$3.10±1.37^{d}$	$3.25±1.45^{b}$	$2.85±1.53^{d}$	$3.25±1.41^{c}$
C3	$2.55±1.23^{h}$	$2.50±1.82^{b}$	$2.35±0.81^{d}$	$3.10±1.59^{d}$	$3.20±1.54^{b}$	$3.40±1.82^{b}$	$3.40±1.88^{b}$
C4	$2.25±1.90^{k}$	$2.40±1.80^{h}$	$2.35±1.09^{d}$	$3.85±1.66^{a}$	$2.10±1.59^{j}$	$2.55±1.50^{e}$	$2.15±1.48^{i}$

Values are in Means of a triplicate data ± STDEV. Means (n) with in a column with the same letter are not significantly different (P>0.05). T1,-----T8 = Samples 1 up to 8 indicating lemon juice extract of different volume from 150mL up to 500mL by 50 mL volume increment. C1=camel milk alone, C2=Camel milk with Rennin enzyme, C3= Cow milk alone, and C4 = Camel milk with Ginger spice, and OAA= over all acceptability.

Keceli et al. (2017) reported that reduction of calcium by pre-acidification of cheese with citric acid affects softening and melting properties of cheese. Such reduction of calcium levels might reduce the hardness of cheese and improve the functional properties of low fat mozzarella cheese (Metzger et al., 2000). As expected, higher lemon juice treatment volumes produced more sour cheese which was better preferred by panelists. Likewise, a higher cheese color acceptability score was found in sample T8 (2.8) with yellowish color, whereas the lower color score was found in sample T1 (1.9) with a moderately white color. This might be due to the combined effect of lemon juice and creamier visual appearance of camel milk (Wernery, 2006).

The highest average sensory odor score was found in Ginger spice (3.85) followed by lemon juice T8 (3.65) preparations whereas the lowest was found in lemon juice T1 (2.0) preparation products. Meanwhile, lemon juice < T8 preparations had lower average odor acceptability score than positive control products. This might be due to strong volatile compounds in the ginger spice together with milky flavor of camel milk.

Cheese flavor is a manifestation of complex interactions of volatile and non-volatile flavor-active compounds plus textural perception (Olson, 1990). In this study, there was a significant variation ($P<0.05$) in the flavor of camel milk cheese between all treatment preparations. The highest score of flavor was found in sample T8 (3.35) followed by Renin control (3.25) preparations whereas the lower score value was found in Ginger spice control (2.1), negative control (2.20) and lemon juice T1 (2.35). Since lemon juice has a strong flavor, the combination of natural milk flavor with more lemon juice appears to produce better acceptable flavor

A higher average appearance score was found in sample T8 (3.80) followed by T7 (3.2) whereas the lower score was found in samples C1 (2.15), T1 - T2 (2.25). Appearance of cheese is a function of the interaction between cheese color and texture, and coagulant type used (Delahunty and Drake, 2004; Lamichhane et al., 2018; Miloradovic et al., 2018; Ortiz Araque et al., 2018). As noted above, higher lemon juice concentration imparted more acceptable yellowish cheese color.

Overall acceptability is the cumulative judgment of panelists on softness, color, sourness character, flavor, odor and appearance of cheese made using lemon juice as coagulant. There was therefore a significantly high ($P<0.05$) score on the overall acceptability of camel milk cheese for sample T8 (3.85) (Table 4). Thus, the addition of more lemon juice to camel milk could result high overall acceptability than other investigated treatments, even from control samples.

4. Conclusion

The study demonstrated that supplementing camel milk with increasing volumes of lemon juice enhanced cheese yield along with an added shelf life extending benefit of higher acidity. Composition wise, former trends were accompanied by increasing cheese energy, fat, moisture, and protein contents but declining TS, ash and lactose contents. Cheese produced by increasing lemon juice treatment of camel milk also showed higher overall sensory acceptability including better softness, color, flavor and appearance. Therefore, current findings indicate that addition of lemon juice to camel milk could offer a suitable means for cheaply producing coagulated milk products such as cheese in pastoralist areas.

List of Abbreviations: AOAC, Association of Official Agricultural Chemists; C1-C4, Control 1 up to Control 4; DMRT, Duncan's Multiple Range Test; ESRS, Ethiopian Somal Regional State; IDF, International Diabetes Federation; IMCU, International Milk Coagulating Unit; LSD, Least Significant Difference; T1-T8, Treatment 1 up to Treatment 8; TN**,** Total Nitrogen; TS, Total Solid.

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Authors Contribution: YM and NT conceived and performed the experiment, YM wrote the manuscript with input from all authors. SA and SF aided in interpreting the results and worked on the manuscript. All authors discussed the results, prepared final draft and approved the manuscript.

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