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**Research article**

# Physicochemical properties of butter made from camel milk alone and blending it with goat milk

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## ABSTRACT

In this study the physicochemical properties of butter made from camel milk alone and at different blending levels were assessed. The experiment was laid out in completely randomized design with five treatments, T1 (100% camel milk), T2 (75% camel and 25% goat milk), T3 (50% camel and 50% goat milk), T4 (25% camel and 75% goat milk) and T5 (100% goat milk). The physicochemical properties of the butter samples were analyzed following standard procedures. The moisture content (39.2%), melting range (42.1$^0$C), refractive index (1.592) and acid degree value (8.72% oleic acid) for T1 was significantly (P<0.001) higher than the other butter samples and T1 had significantly (P<0.001) lower fat content(56.8%) than the other samples. The results showed that blending camel milk with goat milk improved physicochemical properties of butter made from camel milk at different blending levels. 

**Keywords:** Blending, butter, physicochemical properties

## 1. INTRODUCTION

Ethiopia possesses over 2.4 million dromedary camels that stand the country third in Africa in camel population (FAO, 2010). Camels are kept, among other things mainly for milk production in the pastoral areas. They produce milk for quite longer period even during dry periods compared to cattle (Kurtu, 2003). The majority of camels in the country are found in the drier areas of the Eastern part of the country. Dromedary camels are naturally browsers, thrive on sparse pasture and produce milk where other domesticated animals would virtually starve (El Zubeir *et al.*, 2010). This characteristic makes the lactating camel a very valuable animal for the survival of the camel herders and their family in this harsh environment. The annual camel milk production in Ethiopia is estimated 75,000 tones

(Felleke, 2003). Camel milk is an important component of human diet in many parts of the world. The present knowledge about the milk production potential of camels (*Camelus dromedarius*) is very limited. However, a healthy camel on good feed can produce 2,000 liters of milk per lactation period (Knoess *et al.*, 1986). Most of the camel milk is drunk fresh or when it is slightly sour in pastoral areas of the country.

Camel milk is not churnable by the traditional methods owing to the chemical nature of the milk. Therefore, milk produced from camels is primarily used for direct consumption by the pastoralists. Pastoralists claim that it is difficult to churn camel milk to make butter (Yagil, 1985) and further stated that butter from camel milk cannot be obtained so easily using the traditional churning methods because camel milk shows little tendency to cream up and the fat in camel milk is firmly bound to the protein (Rao *et al.*, 1974). Although it is difficult to make butter from camel milk, reports revealed that butter can be made from camel milk by churning fresh or soured camel milk at 24-25$^0$C ( Farah *et al.*, 1991). In the Algerian Sahara, there is a popular butter made from camel milk and is called *Shmen or Semma* (FAO, 1990). In this region, fresh camel milk butter is difficult to preserve because it usually contains many impurities (sand, hair, etc.) and rapidly becomes rancid. The Touaregs (nomad tribe of Sahara) improve the shelf life of camel milk butter by transforming it into clarified butter oil (*Shmen*). This product has been playing a major role in the diet of Touareg communities in the Sahara, and today there is a special demand for this product among consumers.

In pastoral areas, large amounts of camel milk are produced but buttermaking from camel milk is difficult due to the inherent characteristics of the milk. In addition to camel milk, milk from small ruminants particularly goats is also available in pastoral areas. Thus, the possibility exists to make butter from camel milk by blending it with goat milk. Hence, knowledge of the factors that influence buttermaking and the possibilities of churning camel milk to make butter are very important aspects of camel milk processing for enhancing the product, analysis of its quality and value addition of camel milk that will subsequently enrich the diets and income of the pastoralists. Fresh milk is easily perishable if it is not consumed immediately. So when surplus amount of milk is produced, it should be processed into different products like butter, soured milk and cheese. Butter has long shelf life as compared to fresh milk, especially when heated to higher temperature (100-120$^0$C) for 30 minutes it can stay for several months without spoilage (Lejko *et al.*, 2009).

Camel milk butter is believed to have some medicinal properties and laxative properties for gastrointestinal discomfort in different parts of the world (Rao *et al*., 1974). In the Sahara, fresh butter made from camel milk is not usually consumed rather used for medicinal purpose. Camel milk butter is also used in the preparation of nutritious and medical soups. The byproduct of butter, i.e., buttermilk, is used as a functional ingredient in many food products such as salad dressings, pasta sauces, chocolate, cheese seasonings, ice cream mixes, and yoghurt (Fox, *et al.*, 2000). Therefore, buttermaking from camel milk has multi dimensional advantages. It is against this background and justification that this research work was conducted with the following objective.

- To evaluate the physicochemical properties of butter obtained from camel milk alone and at different blending levels.

## 2. MATERIALS AND METHODS

### 2.1. Description of the study area

Goat milk samples for buttermaking were collected from pastoralists in Somali Regional State specifically from Jijiga woreda Hodle Kebele. Jijiga Woreda is one of the six administrative woredas of the Jijiga Zone located at 630 km East of Addis Ababa at a latitude of $9^0$21'N and longitude of $42^0$48'E. The Woreda is characterized by unreliable and erratic rainfall with a precipitation ranging from 300 to 600 mm per annum, high ambient temperatures (>$30^0$C), sparsely distributed vegetation dominated by *Cactus* and *Acacia* species, and bushy woodlands (Bekele, 2001). The altitude of this woreda ranges from 500-1500 meter above sea level. The majority of the camel herders in the woreda are Somali ethnic groups. Numerically, camels are the most abundant domestic animals in the area followed by goats. This area is among the lowlands of the country where large population of camels is found and known for its camel milk production. Camel milk sample for buttermaking were collected from Erer. Erer is situated approximately 25 km, East of the town of Harar at an altitude ranging from 1300 meter above sea level in the south to 1600 meter above sea level in the north. It also represents one of the major camel milk producing areas in the country and has a semi-arid climate. There are two main rainy seasons in Erer, one during March to April and the other during July to September, with a mean annual temperature of 21.75$^0$C. Shrubs and thorny bushes of *Acacia* and *cacti* origin dominate the vegetation (Bekele *et al*., 2002).

### 2.2. Milk Sample Collection

Before collection of camel and goat milk samples from Erer and Hodle Kebele, respectively arrangements were made with local pastoral people to identify the areas with surplus goat and camel milk production. Milk samples were collected from camels and goats from 15 and 35 households, respectively. The camels used for milk collection were at their second stage of lactation and third parity whereas the goats were at their second stage of lactation and fourth parity. After collection, the milk samples were brought to the Dairy Laboratory of Haramaya University by placing it under ice box. For fermenting, the milk 15 airtight plastic Jerican containers (5liter capacity) were purchased from Addis Ababa supermarket. These containers were filled with either pure camel milk or camel milk blended with goat milk at different proportions and the milk samples were kept in the laboratory at room temperature until the required level of acidity, i.e., pH of 4.13, was attained. A total of 20 liters of camel milk and 20 liters of goat milk were collected from the areas mentioned above for buttermaking. However, this amount of milk does not include the samples used for the physicochemical analysis.

### 2.3. Treatments

The experiment had five treatments, i.e., T1, T2, T3, T4 and T5 as shown in Table 1. T1 was 100% camel milk, T2 was mixture of 75% camel milk and 25% goat milk, T3 was 50% camel milk and 50% goat milk, T4 was 25% camel milk and 75% goat milk and T5 was 100% goat milk, which was used as a control. The experiment was repeated three times for each parameter.

**Table 1.** Treatment combinations

| Treatments | Blend level (%) | Amount of milk (liters) |
|---|---|---|
| T1 | 100% camel milk | 4 |
| T2 | 75% camel milk and 25% goat milk | 4 |
| T3 | 50% camel milk and 50% goat milk | 4 |
| T4 | 25% camel milk and 75% goat milk | 4 |
| T5 | 100% goat milk (control) | 4 |

## 2.4. Experimental design

The design for the experiment was completely randomized design (CRD).

The model used was

$Y_{ij} = \mu + ti + \varepsilon_{ij}$

Where

$Y_{ij}$ = the $j^{th}$ observation of the $i^{th}$ treatment

$\mu$ = overall mean

$t_i$ = the treatment effect (blend level) of the $i^{th}$ treatment

$\varepsilon_{ij}$ = the random error

## 2.5. Physicochemical analysis of butter

The physiochemical analysis of butter samples moisture content, fat content, pH, melting range, refractive index and acid degree value were considered. For theses analysis the standard procedure of Association of Official Analytical Chemists (AOAC, 1995) were followed.

## 2.6. Data analysis

Analysis of variance (ANOVA) was used for analyzing the physicochemical properties of butter samples alone and at different blending levels using the General Linear Model (GLM) of SAS (1999). Significant differences were declared at 5% significance level.

## 3. RESULTS AND DISCUSSION

### 3.1. Chemical composition of butter made from camel milk blended with goat milk

The moisture content of butter made from pure camel milk (T1) was significantly (P<0.001) higher than the other butter samples (Table 2). Butter made from pure goat milk had the lowest moisture content as compared to the other butter samples (Table 2). With increased proportion of goats' milk in the blend, decrease in moisture content of butter was observed (Table 2). The moisture content of butter made from pure camel milk in the present study is higher than the finding of (Mourad and Nour-Eddine, 2006) who reported that the moisture content of traditional butter (*Shmen*) made from camel milk in Algeria ranged from 34.44±0.66% to 34.99±0.33%. The moisture contents of butter made from a blend of 25% camel and 75% goat milk (T4) and pure goat milk (T5) observed in the present study are more or less similar to the moisture content of 16% for butter made from cow milk reported by (O'Mahony and Ephraim ,1985)., **(**Idoui *et al.,* 2010) reported that the moisture content of traditional butter made from five fresh cow milk samples collected from different locations of Jijel (Eastern Algeria) ranged from 17.5%-26.5%.

The fat content of butter made from pure camel milk (T1) was significantly (P<0.001) lower than the other butter samples (Table 2). However, no significant difference (P>0.001) in fat content was observed in butter samples from T1 and T2. While no significant difference (P>0.001) was observed in blend butter samples (T3, T4) and pure goat milk (T5) (Table 2). With increased proportion of goats' milk in the blend, an increase in fat content of butter was observed (Table 2). The fat content of butter made from pure camel milk observed in the present study is similar to the finding of (Mourad and Nour-Eddine ,2006) who reported that the fat content of traditional butter (*Shmen*) made from camel milk in Ain-Safra, Mograr, Bechar and Saida regions of Algeria was 56.05±0.09, 58.13±0.03, 56.20±0.07 and 49.90±0.11%, respectively.

The pH of butter made from pure goat milk (T5) was significantly (P<0.001) lower than the pH of butter made from blended milk (T2, T3 and T4) (Table 2). The pH of butter made from pure camel milk (T1) observed in the present study is in line with the findings of (Mourad and Nour-Eddine, 2006) who reported that the pH values of traditional butter (*Shmen*) made from camel milk in Ain-Safra, Mograr, Bechar and Saida regions of Algeria were 4.87±0.23, 3.10±0.26, 4.97±0 32 and 4.38±0.33, respectively. However, it is lower than pH value of cow milk butter reported by (Idoui *et al.,* 2010) indicated that the pH values of traditional butter made from five fresh cows' milk samples collected from different locations of Jijel (Eastern Algeria) ranged from 4.64-5.53.

The melting range of butter made from pure camel milk (T1) was significantly (P<0.001) higher than the other butter samples (Table 2). On the other hand, the melting range of butter made from pure goat milk (T5) was significantly (P<0.001) lower than the other butter samples (Table 2). With increased proportion of goats' milk in the blend, a decrease in melting range of butter was observed (Table 2). The melting range of butter made from pure camel milk (T1) observed in the present study is higher than the findings of (Abu-Lehia, 1989) and (Ruegg and Farah,1991) who reported melting range of camel milk butter fat to be 41.9±0.9$^0$C and 30.5±2.2$^0$C, respectively. It was reported that camel milk fat contains a lower amount of short chain fatty acids ($C_4$ - $C_{12}$) and a higher amount of

long chain fatty acids ($C_{14}$-$C_{22}$) compared with bovine milk fat (Abu-Lehia, 1989; Haddadin *et al.*, 2008 and Ruegg and Farah, 1991). The lower melting range observed in butter samples made from pure goat milk (T5) could be attributed to the fact that goats' milk contains higher proportions of short chain ($C_4$ - $C_{10}$) fatty acids which have low melting point. This narrow melting range provides for a quick flavor release and smooth mouthfeel.

The acid degree value (hydrolytic rancidity**)** of butter samples made from pure camel milk (T1)) was significantly ($P<0.001$) higher than the rest (Table 2), whereas the acid degree value of butter made from pure goat milk (T5) was significantly ($P<0.001$) lower than the other butter samples (Table 2). A decrease in acid degree value (hydrolytic rancidity) was observed with an increase in proportion of goats' milk in the blend (Table 2). Acid degree value indicates the amount of free fatty acids present in a fat as a result of lipolysis. The low acid degree value in butter samples made from pure goat and blended milk indicates few free fatty acids in the butter samples. This in turn indicates that butterfat at different blend levels has not undergone undesirable hydrolysis, which results in flavor defects. Lipid deterioration according to (Ihekoronye and Nogoddy, 1985) is a major problem in the storage of many foods especially those with high fat content. One of the major changes taking place in lipids is rancidity during which ester linkages of the lipids are hydrolyzed by lipolytic enzymes which results in release of free fatty acids. The degree of lipolysis in butter varies widely and related with lipases in butter that originate from milk and nonstarter bacteria. (Klnlk *et al*., 1999) also stated that the reasons of variations in lypolysis butter samples could originate from difference in microbial loads and variations in production methods. The acid degree value of butter made from camel milk in the present study is higher than the finding of (Abdalbasit *et al*., 2010) who reported acid degree value of 1.21±0.07 to 2.58±0.2 for butter made from cow milk produce in Khartoum North, Sudan.

The refractive index of butter made from pure camel milk (T1) was significantly ($P<0.001$) higher than the other butter samples (Table 2). However, no significant difference ($P>0.001$) in refractive index was observed between the other butter samples (T2, T3, T4 and T5) (Table 2). The refractive index of butter made from camel milk in the present study is in line with the finding of (Abdalbasit *et al*., 2010) who reported a refractive index of 1.4627±0.08 to 1.4670±0.2 for butter made from cow milk produce in Khartoum North, Sudan. The refractive index is related to the ease with which light passes through butterfat. Refractive index value can be used as an indirect measurement of unsaturation. Temperature and degree of saturation affect the refractive index value of butter.

In general, the results of the physicochemical analysis of butter samples indicate that butter made from pure camel milk (T1) had the lowest physicochemical quality compared to the other butter sample. The results of physicochemical quality of blended butter samples (T2, T3 and T4) had improved. It could be attributed to blending effect of goat milk at different proportion. This calls for the need for blend of goat milk improving physicochemical quality on camel milk. However, one of the shortcomings observed during physicochemical quality analysis from pure camel milk was the lowest. Thus, research is needed to increase the physicochemical quality of camel milk by blended with goat milk at different proportion.

**Table 2.** Chemical composition of butter made from camel milk blended with goat milk

| Parameters | Blend levels |
|---|---|

| | T1 | T2 | T3 | T4 | T5 |
|---|---|---|---|---|---|
| Moisture (%) | $39.20^{a}\pm2.47$ | $32.97^{b}\pm3.77$ | $24.07^{c}\pm2.57$ | $15.50^{d}\pm1.67$ | $14.27^{d}\pm2.07$ |
| Fat (%) | $56.80^{b}\pm2.46$ | $60.57^{b}\pm3.32$ | $74.10^{a}\pm6.01$ | $76.57^{a}\pm10.03$ | $80.00^{a}\pm4.99$ |
| pH | $4.25^{bc}\pm0.13$ | $5.31^{a}\pm0.84$ | $4.92^{ab}\pm0.52$ | $5.41^{a}\pm0.21$ | $4.08^{c}\pm0.16$ |
| MR ($^{0}$c) | $42.00^{a}\pm1.00$ | $33.00^{b}\pm1.00$ | $24.50^{c}\pm0.50$ | $17.00^{d}\pm1.00$ | $11.00^{e}\pm1.00$ |
| RI | $1.592^{a}\pm0.064$ | $1.460^{b}\pm0.006$ | $1.464^{b}\pm0.001$ | $1.458^{b}\pm0.001$ | $1.493^{b}\pm0.003$ |
| ADV(%O.A) | $8.72^{a}\pm0.42$ | $7.83^{b}\pm0.24$ | $5.84^{c}\pm0.02$ | $3.23^{d}\pm0.14$ | $2.44^{e}\pm0.23$ |

*MR = melting range; RI = refractive index; ADV(%O.A) = acid degree value % of oleic acid; T1 = 100% camel milk type; T2 = 75% camel+25% goat milk type; T3 = 50% camel+50% goat milk type; T4 = 25% camel+75% goat milk type and T5 = control (100% goat milk); Means with different superscript letters in a row are significantly different ($P<0.001$); values in the table are means±SD of three replications; ADV = acid degree value.

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