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Physicochemical properties of butter made from camel milk

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ABSTRACT

The making of butter from camel milk using a traditional churning method and the physicochemical properties of the butter were assessed. Camel milk was obtained from pastorally managed camels in the Erer valley, eastern Ethiopia. Churning time, butter yield and fat recovery efficiency of camel milk were 120 min, 43 g L^{-1} and 79.8%, respectively. Camel milk butter had average values of 64.1 ± 5.2%, 55.8 ± 1.6%, 6.7 ± 2.5 mg KOH g^{-1}, 4.90 ± 0.15, 43.2 ± 0.8 °C and 1.4530 ± 0.0002 for total solids, fat, acid degree value, pH, melting point and refractive index, respectively. The results showed the possibility of making butter from camel milk; however, further research is needed to reduce churning time and improve butter yield.

1. Introduction

Ethiopia has about 2.4 million dromedary camels (FAOSTAT, 2009). Camels are kept mainly for milk production in the pastoral areas of the country. The majority of camels in the country are found in the drier areas of the eastern part of the country. They produce milk for a longer period even during the dry season compared with cattle (Tafesse, Mekuriaw, & Baars, 2002). This characteristic makes the lactating camel a very valuable animal for the survival of the camel herders and their families in this harsh environment. The annual camel milk production in Ethiopia is estimated at 75,000 tons (Felleke, 2003).

Pastoralists claim that it is difficult to churn camel milk into butter. Previous reports indicated the difficulty of making butter from camel milk (Yagil, 1982; Yagil, Zagorski, van Creveld, & Saran, 1994). Butter from camel milk cannot be easily made using traditional churning methods because it shows little tendency to cream up due to lack of the protein, agglutinin (Mulder & Walstra, 1974). The difficulty of making butter from camel milk is also attributed to the fact that the fat in camel milk is distributed as small micelle-like globules (Yagil & Etzion, 1980) and it is firmly bound to the protein (Khan & Appena, 1967). Moreover, the fat globule membrane of camel milk is thicker than that of the cow (Knoess, Makhudum, Rafiq, & Hafeez, 1986).

Despite this, pastoralists in the Algerian Sahara make butter called Shmen from camel milk by a traditional agitation method (Mourad & Nour-Eddine, 2006). Farah and Streiff (1987) and Yagil (1982) also reported that pastoralists in northern Kenya and Bedouins in the Sinai Peninsula, respectively, traditionally make butter from camel milk. Moreover, the possibility of making butter from camel milk was also reported by Farah, Streiff, and Bachmann (1989) and Knoess et al. (1986). This butter is used for medicinal purposes or as hair pomade.

Butter is believed to have some medicinal and laxative properties for gastrointestinal discomfort in different parts of the world (Yagil, 1982). Butter is also used as an ingredient during cooking of foods. Thus, buttermaking from camel milk will enable production of a product with high consumer demand because of its unique properties and will fetch a premium for the pastoralists. This study was, therefore, conducted to assess the possibility of making butter from camel milk using a traditional churning method and to determine the physicochemical properties of the butter.

2. Materials and methods

2.1. Milk sample collection

Camel milk samples were collected from pastorally managed camels in Erer valley, eastern Ethiopia in December 2010. Four litre composite samples were placed in a container (bucket) and kept at room temperature (22–23 °C) for spontaneous fermentation to take place. Milk samples were collected three times from the same source and analysed separately.

2.2. Buttermaking

Before commencing the actual experiment, preliminary experiments were conducted to standardise the buttermaking

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procedure. Churning of the sour milk was conducted at a pH value of 4.10 and at 22–23 °C. This churning temperature was based on the recommendation of Farah et al. (1989). The temperature of the sour milk was adjusted just before churning by putting the container filled with milk into a vat of hot water. Then the milk was stirred and the temperature measured using a thermometer. Finally, the milk was removed from the hot water and churned immediately. The method of agitation used was rapid swaying of the churn by up and downward movement after hanging the container on a pole using a rope. This method of churning was found to be easy because it only requires application of force in the upward direction whereas the downward movement occurs by gravitation. Four litres of sour milk was churned at a time in a Jerican (Viking, Pasir Gudang Edible Oils Son, BHD, Johor, Malaysia) of 20 L capacity. The buttermaking experiment was repeated three times.

2.3. Physicochemical properties

Total solids content of the butter samples was determined according to Marth (1978). The melting point of butter was determined by capillary tube method according to AOAC (1995) method 920.157 using Gallenkamp Melting Point Apparatus (MPA350BM250, London, UK). The pH of butter samples was measured using a digital pH meter (pH Model 510, Eutech Instruments Pltd., Malaysia) according to Marth (1978). Refractive index was determined according to AOAC (1995) method 969.18 using a digital Refractometer (RFM330, Bellingham + Stanley Limited, Tunbridge Wells, UK). The acid degree value expressed as the number of milligrams of KOH required to neutralise the acids found in 1 g of fat was determined according to AOAC (1995) method 969.17. Fat content of butter samples was determined according to Marth (1978) using the Roese–Göttlieb extraction method. Fat recovery efficiency was calculated as the ratio of fat percent of whole milk minus fat percent of buttermilk over fat percent of initial milk samples. Fat content of milk samples was determined by the Gerber method (Marth, 1978).

2.4. Fatty acid analysis

The fatty acid composition of the butter samples was analysed according to Christie (1989). Fatty acid methyl esters of butterfat samples were prepared using 2 M methanolic potassium hydroxide solution and extracted with 15 mL of N-hexane and dried over anhydrous $CaCl_2$ salt. An aliquot of the supernatant was analysed for free fatty acids using gas chromatography (GC1000, DANI Instruments SPA, Pavia, Italy) equipped with flame ionisation detector and a polar capillary column: ECTM-5 (30 m × 0.32 mm × 0.25 μm film) with a mobile phase of 5% phenyl and 95% methylpolysiloxane. The column length was 30 m. The operational conditions were: injector temperature 210 °C, detector temperature 260 °C and the column temperature was initially adjusted to 50 °C for 2 min, and then increased by 4 °C per minute until it reached 250 °C after which it was held for 15 min. The carrier gas used was nitrogen at a flow rate of 1 mL per min. The analysis was conducted in the Chemistry Department of Addis Ababa University. A total of three samples were used and each sample was analysed in triplicate.

2.5. Data analysis

Descriptive statistics such as mean and percentage were used to analyse the data using SAS (2002) version 9.

3. Results and discussion

3.1. Buttermaking process

The traditional churning method used in the present study exerts a higher churning force that facilitates butter extraction from camel milk compared with the common back- and fro-agitation method. The need for vigorous shaking of fermented camel milk for production of butter was reported by Yagil (1982). This might be due to the inherent characteristic of camel milk fat as camel fat globules to be firmly bound to proteins (Khan & Appena, 1967), have smaller size (Yagil & Etzion, 1980) and thicker membrane compared with the fat globule membranes of cow milk fat (Knoess et al., 1986). As a result, more force is required to rupture the fat globule membrane from the fat and allow the globules to adhere to one another. Collection of camel milk butter grains was best done by using muslin cloth versus by hand as with cow milk. This was because of the small size of the grains that were sparsely dispersed on the surface of the buttermilk and also the white colour of camel milk butterfat is similar to the colour of the buttermilk. The white colour of camel milk butter may be attributed to the low β-carotene content of camel milk (Abu-Lehia, 1989).

3.2. Physicochemical properties

Table 1 presents churning efficiency and physicochemical properties of butter made from camel milk. Churning time for camel milk was found to be 120 min. This churning time is much less than the 4 h reported earlier by Yagil (1982). Butterfat recovery efficiency of approximately 80% observed in the present study (Table 1) is higher than the 60% reported by Farah (1996) for camel milk.

The total solids (TS) content of camel milk butter observed in the present study is similar to the TS values (64–65%) reported by Mourad and Nour-Eddine (2006). Fat content of the butter observed in the present study is in line with the values 55–59.6% and 49–58% reported by Farah et al. (1989) and Mourad and Nour-Eddine (2006), respectively. However, Farah et al. (1989) reported that a fat percentage of as high as 85% was achieved when sweet camel milk cream was used.

Acid degree value (ADV) of fat is a measure of the free fatty acid content and thereby of the degree of rancidity of the fat. Butter in the present study had an (Table 1) acid degree value that is in line with the findings of Abu-Lehia (1989), who reported that the acid value of Majaheem camel milk fat was significantly lower than that of cow milk fat. The lower ADV of camel milk butterfat suggests that camel milk butter is less prone to rancidity.

The pH observed in the present study is in agreement with pH values (3.11–4.97) reported by Mourad and Nour-Eddine (2006) for camel milk butter. Similarly, the melting point (43.2 °C) of butter

Table 1
Churning efficiency and physicochemical properties of butter made from camel milk.[a]

Variables	Camel milk/butter
Butter yield (g L^{-1} of milk)	43.0 ± 3
Churning time (min)	120 ± 3.00
Fat recovery (%)	79.8 ± 3.4
Total solids (%)	64.1 ± 5.2
Fat (%)	55.8 ± 1.6
pH	4.90 ± 0.15
Melting point (°C)	43.2 ± 0.8
Refractive index	1.4530 ± 0002
ADV (mg KOH g^{-1} fat)	6.7 ± 2.5

[a] Values in the table are mean ± SD of three replicates; ADV, acid degree value.

samples in the current study is in agreement with the values (41.4–44.1 °C) reported by El-Agamy (2006) for camel milk butterfat. The high concentration of long chain fatty acids (C14–C18) and low proportion of short chain fatty acids (C4–C12) in the camel milk butterfat (Table 2) may have contributed to the high melting point of camel milk butterfat observed.

The refractive index (RI) observed in camel milk butterfat in the present study (1.4530) falls in the range (1.4490–1.4714) reported by El-Agamy (2006). However, it is higher than the RI value (1.4490) reported by Orlov and Servetnik-Chayala (1984). The higher RI value observed might be due to the higher proportion of long chain fatty acids (C14–C18) found in camel milk butterfat (El-Agamy, 2006).

The proportion of short chain fatty acids (C4:0–C12:0) was lower than the proportion of long chain fatty acids (C14–C18) in the present study (Table 2), 3.0% and 97%, respectively. This is in line with the findings of earlier studies. Konuspayeva Lemarie, Faye, Loiseau, and Montet (2008) reported that camel milk fat has lower proportions (1.16%) of short-chain fatty acids and high proportions (80.36%) of long-chain fatty acids. Similarly, Attia, Kherouatou, Fakhfakh, Khorchani, and Trigui (2000) reported that analysis of fatty acid composition of dromedary milk fat showed the presence of very small amounts of short-chain fatty acids (C4–C12) and a higher content of 16:1 and 18:0. It also agrees with the findings of Karray, Danthine, Blecker, and Attia (2006) who indicated that camel milk fat has high proportions of high-melting point triacylglycerols that involves fatty acids with long chains. The types of fatty acids present in butter determine the properties of the butter. Fats with a high content of high-melting point fatty acids is hard; however, fats with a low content of low-melting point fatty acids makes soft butter (Bylund, 1995).

Camel milk butter had a high proportion (32.2% of the total fatty acids) of monounsaturated fatty acids (C16:1 and C18:1) (Table 2) and this is advantageous from nutritional point of view. The high proportion of unsaturated fatty acids observed in the present study is in agreement with the reports of Faye, Konuspayeva, Narmuratova, and Loiseau (2008) and Konuspayeva et al. (2008). Faye et al. (2008) reported that dromedary camel milk had higher proportions (27.6%) of mono-unsaturated fatty acids compared with mare, goat and cow milk. Similarly, Konuspayeva et al. (2008) indicated that camel milk fat has higher contents of unsaturated fatty acids than cows' milk. The proportion of butyric acid (C4:0 = 0.70%) was much lower than the proportion of other short-chain fatty acids (Table 2). This is in agreement with the findings of Konuspayeva et al. (2008) who reported that camels' milk had lower percentages (0.37%) of butyric acid. Short-chain fatty acids play an important role in butter's flavour. Butyric acid is the most widely known and most potent short-chain fatty acid that provides an intense fatty acid-type flavour to butter. Although sensory analysis of butter was not done in the present study, an observation during the execution of the experiment revealed that camel milk butter had less intense flavour as compared with cow milk butter and this could be attributed to the low butyric acid content in the butter samples.

Table 2
Fatty acid composition of camel milk butter.[a]

Fatty acids	Proportion (percent weight)
C4:0	0.70
C6:0	0.39
C8:0	0.24
C10:0	0.34
C12:0	0.87
C14:0	12.14
C16:0	32.04
C16:1	7.73
C18:0	11.85
C18:1	20.10

[a] Values in the table are means of three replications.

4. Conclusion

This study revealed the possibility of making butter from camel milk by a traditional churning method. This is significant to camel milk producing pastoralists to help them add value to their camel milk and generate income from sale of camel milk butter. Although it was possible to make butter from camel milk, it took long time to churn the milk. Thus, further research is needed to reduce the churning time and improve butter yield.

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References

Abu-Lehia, I. H. (1989). Physical and chemical characteristics of camel milk fat and its fractions. *Food Chemistry, 34*, 261–272.
AOAC. (1995) (16th ed.).*Official methods of analysis*, Vol. 2, Washington, DC, USA: Association of Official Analytical Chemists. Chapt. 33, p. 56F.
Attia, H., Kherouatou, N., Fakhfakh, N., Khorchani, T., & Trigui, N. (2000). Dromedary milk fat: biochemical, microscopic and rheological characteristics. *Journal of Food Lipids, 7*, 95–112.
Bylund, G. (1995). *Dairy processing handbook*. Lund, Sweden: Tetra Pak. pp. 13–36.
Christie, W. (1989). *Gas chromatography and lipids*. Glasgow, Scotland: The Oily Press Ltd. p. 39.
El-Agamy, E. I. (2006). Camel milk. In Y. W. Park, & G. F. W. Haenlein (Eds.), *Handbook of milk of non-bovine mammals* (pp. 297–344). Iowa, OH, USA: Blackwell Publishing Professional.
FAOSTAT. (2009). *Production statistics. Live animals*. FAO Statistics Division. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO). Retrieved 27.11.11, from. http://faostat.fao.org/site/573/default.aspx#ancor.
Farah, Z. (1996). *Camel milk: Properties and products*. St. Gallen, Switzerland: Swiss Centre for Development Cooperation in Technology and Management (SKAT). pp. 47–51.
Farah, Z., & Streiff, T. (1987). *Production of cultured milk and butter from camel milk*. Report on Field Studies in Kenya. Zurich, Switzerland: Swiss Federal Institute of Technology Zurich (ETHZ). p. 22.
Farah, Z., Streiff, T., & Bachmann, M. R. (1989). Manufacture and characterization of camel milk butter. *Milchwissenschaft, 44*, 412–414.
Faye, B., Konuspayeva, G., Narmuratova, M., & Loiseau, G. (2008). Comparative fatty acid gross composition of milk in Bactrian camel and dromedary. *Journal of Camelid Science, 1*, 48–53.
Felleke, G. (2003). *A review of the small-scale dairy sector in Ethiopia*. Rome, Italy: Food and Agriculture Organization of the United Nations. Retrieved 11.03.11, from. http://www.fao.org/ag/againfo/projects/en/pfl/documents.html.
Karray, L. N., Danthine, S., Blecker, C., & Attia, H. (2006). Contribution to the study of camel milk fat globule membrane. *International Journal of Food Science and Nutrition, 57*, 382–390.
Khan, K. U., & Appena, T. C. (1967). Carotene and vitamin A in camel milk. *Journal of Nutrition and Dietetics, 4*, 17–20.
Knoess, K. H., Makhudum, A. J., Rafiq, M., & Hafeez, M. (1986). Milk production potential of the dromedary with special reference to the province of Punjab, Pakistan. *World Animal Review, 57*, 11–21.
Konuspayeva, G., Lemarie, E., Faye, B., Loiseau, G., & Montet, D. (2008). Fatty acid and cholesterol composition of camel's (*Camelus bactrainus*, *Camelus dromedarius* and hybrids) milk in Kazakhstan. *Dairy Science and Technology, 88*, 327–340.
Marth, E. H. (1978). *Standard methods for the examination of dairy products* (14th ed.). Washington DC, USA: American Public Health Association. pp. 239–361.
Mourad, K., & Nour-Eddine, K. (2006). Physicochemical and microbiological study of *"Shmen"*, a traditional butter made from camel milk in the Sahara (Algeria): isolation and identification of lactic acid bacteria and yeasts. *Grasas Y Aceites, 57*, 198–204.
Mulder, H., & Walstra, P. (1974). *The milk fat globule*. Wageningen, The Netherlands: Pudoc. p. 147.
Orlov, V. K., & Servetnik-Chayala, G. K. (1984). Some physical and chemical characteristics of fat and fatty acid composition of lipids of camel milk. *Dairy Science Abstract, 44*, 7044.
SAS. (2002). *SAS/STAT guide to personal computers, version 9*. Cary, NC, USA: Statistical Analysis System Institute Inc.

Tafesse, B., Mekuriaw, Z., & Baars, R. M. T. (2002). Milk production performance of the one humped camel (*Camelus dromedarius*) under pastoral management in semi-arid eastern Ethiopia. *Livestock Production Science, 76*, 37–44.
Yagil, R. (1982). *Camels and camel milk*. FAO Animal Production and Health Paper. No. 26. Rome, Italy: Food and Agriculture Organization of the United Nations. p. 69.
Yagil, R., & Etzion, Z. (1980). The effect of drought conditions on the quality of camels' milk. *Journal of Dairy Research, 47*, 159–166.
Yagil, R., Zagorski, O., van Creveld, C., & Saran, A. (1994). Science and camel's milk production. In G. Saint Marin (Ed.), *Chameux et dromedaries, animeaux laitiers* (pp. 75–89). Paris, France: Expansion Scientifique Français.