Camel milk cheese: optimization of processing conditions

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Abstract

Making cheese from camel milk is considered to be a difficult task. A study was conducted to optimize the processing conditions (temperature, pH, $CaCl_2$ and the addition of buffalo milk) for the production of camel milk cheese (CMC). In the preliminary trials, the heating temperature of 65 °C for 30 min was found optimal when considering the cheese yield out of 60-75 °C for 30 min. A range of pH levels (5.5, 5.7, 6.0, 6.3, 6.5) were then trialed in order to determine the optimal level necessary to manufacture cheese with the desired characteristics of acidity, protein, fat, moisture, yield, percentages, coagulation time and texture of cheese. On the basis of composition (protein 16.47%, fat 16.67%, moisture 68.4%), texture (6.7 N) and coagulation time (37.7 min), the cheese manufactured at pH.5.5 was selected from the five treatments. In the next stage, CMC was prepared with the addition of $CaCl_2$ (0.02, 0.04, 0.06, 0.08%) at the chosen pH of 5.5 from the previous study. The conditions containing 0.06% $CaCl_2$ resulted in a higher yield with an improved coagulation time and texture of CMC. In the final step, buffalo milk (0, 10, 20, and 30 %) was mixed with the camel milk in an attempt to produce CMC with improved texture. The addition of 10% buffalo milk was selected for the production of CMC based on the textural properties.

Keywords: Camel milk cheese, temperature, pH, $CaCl_2$, buffalo milk, yield

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Introduction

The camel population in Pakistan is estimated to be about 1.0 million head, the 8th largest in the world with a total annual milk production of 818 million liters. Camels are mostly located in arid and semi- arid region of Punjab, Sindh and some hilly areas of Khyber Pakhtunkhwa and Baluchistan provinces (Abid *et al*. 2013). The Brala breed, with an average milk yield of 4179 liters per year, is probably the best milk producer in the world (Faraz *et al*., 2013). The consumption of milk improves the health of nomadic desert people who face harsh weather conditions. The milk composition usually varies and contains proteins (2.5-4.5%), fat (2.9-5.5%), lactose (2.9-5.8%), solids-not-fat (8.9-14.3%) and ash (0.35-0.95%). It provides vitamins A, C, D, B_1, B_2 and B_{12}. The concentration of vitamin C is three times that of cow milk and two times that of human milk (Mehaia, 1994; Aleme and Yusaf, 2014).

Traditionally, camel milk is consumed in a fresh and naturally fermented sour milk named Dhanaan in Ethiopia (Eyassu, 2007), Gariss in Sudan (Warda *et al*. 2008), Suusac in Kenya (Tezira *et al*. 2005), and in the form of yogurt and soft cheese in many other areas. Cheese making from camel milk is more complicated than that of cow, sheep or goat milk. This is mainly due to its low level of total solids, unique composition of casein with a lower amount of kappa casein (Farah and Atkins, 1992) and presence of high concentration of lysozymes and lactoferrins that are mainly affected by the hot seasons and a shortage of feed and water. Several problems are faced when processing such as coagulation time, rennet concentration, temperature, $CaCl_2$ concentration and selection of culture (Al Haj and Al-Kanhal, 2010).

Regarding these factors, two small-scale projects have been developed to manufacture cheese from camel milk in Saudi Arabia and Tunisia (Ramet, 2001) while commercial productions are carried out in Mauritania and Dubai. In Pakistan, no serious effort was made to evaluate the effect of processing conditions on the quality and yield of camel milk cheese. Therefore, this research project was designed to determine the optimal conditions for cheese making from camel milk, which could assist producers to transform their camel milk into cheese at cottage level.

Materials and methods

Whole fresh camel milk of Brala breed was obtained from a private farm near Faisalabad. The milk samples were immediately cooled to 4±1 °C and transported to the Dairy Laboratory at the National Institute of Food Science and Technology (NIFSAT), University of Agriculture, Faisalabad, Pakistan. The thermophilic starter culture (*Lactobacillus thermophilus* and *Lactobacillus bulgaricus*) and camel rennet were procured from Chr. Hansen Ireland Ltd. The camel cheese was prepared following the method of Shahein *et al*. (2014), with some modifications in the process. The processing conditions such as pasteurization temperature, pH, addition of $CaCl_2$ and blending buffalo milk with camel milk were optimized for the production of camel milk cheese.

At the first stage the pasteurization temperature was optimized (keeping duration constant at 30 min) based on the yield after 45 min to coagulation. In the 2nd stage the pasteurized milk was acidified at different pH before cheese production and an optimal pH was selected based on yield and composition. In the 3rd phase, pasteurized (65 °C for 30 min) milk was acidified (pH 5.5) and different levels of $CaCl_2$ (0.02 to 0.08%) were added and in the 4th phase, camel milk blend with buffalo milk (10 to 30%) was pasteurized, acidified and $CaCl_2$ was added to it for the cheese production.

Physico-chemical analysis of cheese

The cheese samples were prepared in duplicate and analyzed in triplicate for the different variables. All the samples were evaluated for pH (Ong *et al*. 2007) using a pH meter (Hanna, HI-99161, Woonsocket RI, USA), acidity was measured by titrimetric method (Method No. 920.124 of AOAC, 2000), total nitrogen by Kjeldahl method (method No. 20B, IDF 1986), crude protein was calculated as total nitrogen X 6.38, fat by Gerber method (Marshall, 1992), moisture content (method No. 926.08 of AOAC, 2000), solids-not-fat (David, 1977) and texture using Stable Micro System (TA.XT plus texture analyser, Surrey, UK).

Statistical analysis

Data was analyzed statistically by analysis of variance (ANOVA) of the complete randomized design.

Results and discussion

Pasteurization temperature had significant effect ($P<0.05$) on yield (Table 1). The highest yield of 22.20% was obtained at 65 °C. However, further increase in temperature resulted in lower yield. Camel milk is less heat stable at high temperature which might be due to lack of β-lactoglobulin as this protein forms a complex with ƙ-casein in cow and buffalo's milk and makes the whey proteins stable at high temperature (Fox, 1981; Farah and Atkins.1991). Investigations show that ƙ-casein and β -lactoglobulin play an important role in heat coagulation (Al-Saleh, 1996; Farah, 1993).

Table 1. Effect of pasteurization temperature on yield of camel milk cheese

Pasteurization temperature	Yield* (%)
60 °C for 30 min	21.20 ± 0.60^{a}
65 °C for 30 min	22.00 ± 0.29^{a}
70 °C for 30 min	14.67 ± 0.33^{b}
75 °C for 30 min	9.67 ± 0.33^{c}

*values are the means of triplicate measurements; ^{a,b,c} Values in the same column with different letters are different ($P<0.05$).

The impact of pH on composition, yield, coagulation time and texture is illustrated in Table 2. The results revealed the significant effect of pH on all the parameters of cheese except fat contents. Acidity, protein, moisture and hardness increased ($P<0.05$) as pH decreased while yield and coagulation time decreased ($P<0.05$). The shortest coagulation time of 37.67 min was observed at pH 5.5 with 21.77 % yield and 68.37% moisture. Farah and Bachmann (1987) reported that lowering pH to 5.6 resulted in reduction of coagulation time. Reduction in coagulation time with lowering the pH could be due to the enhancement of charge neutralization process and conformational changes during the second phase of coagulation (Mahaia, 1993). Camel milk is known for its stronger buffering capacity compared to bovine milk (Dian and Bai, 2014). Therefore, buffering capacity of milk may influence many of its physico-chemical

properties (Dian and Bai, 2014). Higher moisture content due to relatively low Ca-to-casein ratio in direct acidified cheese (DAC) was reported by Guinee *et al.* (2002), to be conducive to a greater degree of casein hydration. Pastorino *et al.* (2003) correlated the increase in protein contents due to the contraction of protein aggregates below pH 5.5, which result in harder texture.

The effect of $CaCl_2$ on camel milk cheese is illustrated in Table 3. The results show that an increase in $CaCl_2$ has significant ($P<0.05$) effect on yield and improvement in texture with lowering moisture content. Keller *et al.* (1974) reported a linear increase in the moisture content of directly acidified Mozzarella cheese as the Ca level was decreased in the cheese. This was attributed to the relatively lower amount of ƙ-casein and difference in size of casein micelles. It is reported that camel milk has larger size casein micelle and more reduced ƙ-casein content than bovine milk (Ali and Robinson, 1985; Farah and Atkins, 1992). The large-sized micelles of camel milk are known to be lower in Ca than the smaller ones in bovine milk. The major role of Ca in the coagulation process is influenced by the fact that enrichment of camel milk with ionic Ca drastically decreases clotting time and reinforces the gel strength more than in cow's milk under similar conditions (Ramet, 1987; Farah and Bachmann, 1987). Results from other studies showed that addition of $CaCl_2$ increases the firmness and elasticity in camel milk, cheese and yogurt (Hashim *et al.* 2009). Lydia (2015) also found that extra calcium added at the beginning of cheese making would improve coagulation time but drained away by lowering the pH during cheese making. This minimizes potential defects associated with excess calcium in the final cheese, increasing hardness and arrangement of pores within the microstructure. The extra $CaCl_2$ is also responsible for the bitter taste.

The effect of buffalo milk blend with camel milk in cheese production is presented in Table 4. The results revealed the significant influence of buffalo milk addition on different parameters of cheese. The highest yield of 27.33% ($P<0.05$) was obtained with 30% buffalo milk and 70% camel milk. Imtiaz *et al.* (2012) described that an increase in yield is due to the higher amount of total soluble solids present in buffalo milk .The total protein, casein proteins, fat, lactose and solids-not-fat are higher in buffalo milk than cows' milk and the rheological properties of curd are improved as the total solids in the milk are increased. However, low total soluble contents are the prominent feature of camel milk as compared to bovine milk (Omer and Eltinay, 2009). Therefore, blending with buffalo milk improves the yield and other quality attributes. Shahein *et al.* (2014) reported that mixing camel milk with buffalo milk reduced rennet coagulation time, increased soft cheese yield, total solids, fat, ash and protein contents. Based on the texture of camel milk cheese, the blend containing 10% buffalo was selected for the cheese as the higher levels make more firm cheese, which is not the characteristic of camel milk cheese.

Table 2. Effect of pH on the physico-chemical characteristics, yield, coagulation time and texture of camel milk cheese

pH	Acidity (%)	Crude protein (%)	Fat (%)	Moisture (%)	Yield (%)	Coagulation time (min)	Texture (N)
6.5	0.15±0.003^{d}	13.83±0.44^{C}	15.37±0.33	73.73±0.12^{a}	28.50±0.29^{a}	92.67±1.45^{a}	4.8±0.02^{c}
6.3	0.18±0.006^{c}	13.83±0.17^{C}	15.53±0.33	73.13±0.19^{a}	28.90±0.26^{a}	82.67±1.45^{b}	5.2±0.05^{c}
6.0	0.22±0.003^{b}	15.10±0.15^{b}	15.97±0.33	73.17±0.17^{a}	27.90±0.21A^{b}	64.00±1.00^{c}	6.1± 0.04^{b}
5.7	0.24±0.003^{b}	15.10±0.10^{b}	16.33±0.33	71.23±0.15^{b}	26.60±0.31^{b}	52.33±1.45^{d}	6.5±0.03^{a}
5.5	0.27±0.006^{a}	16.47±0.26^{a}	16.67±0.33	68.37±0.27^{c}	21.77±0.37^{c}	37.67±1.45^{e}	6.7± 0.05^{a}

Values are the means of triplicate measurements; ^{a,b,c,d,e} Mean values in the same column with different superscripts are different (P<0.05).

Table 3. Effect of $CaCl_2$ on physico-chemical, yield, coagulation time and texture on camel milk cheese

$CaCl_2$ level (%)	Crude protein %	Moisture %	Fat %	Yield %	Coagulation time (min)	Texture
0.02	20.67±0.44^{b}	65.67±1.15^{a}	16.33±0.33	19.67±0.33^{c}	51.23±1.25^{a}	5.23±0.07^{d}
0.04	20.67±0.60^{b}	65.67±1.76^{a}	16.67±0.33	20.67±0.67^{b}	48.55±1.56^{b}	5.73±0.03^{c}
0.06	21.40±0.38^{a}	64.67±1.45^{b}	16.17±0.17	23.33±0.88^{a}	43.23±1.26^{c}	6.54±0.06^{b}
0.08	20.33±0.67^{b}	64.67± .67^{b}	16.17±0.17	20.67±0.88^{b}	39.15±1.22^{d}	6.72±0.06^{a}

Values are the means of triplicate measurements; ^{a,b,c,d} Mean values in the same column with different superscripts are different (P<0.05).

Table 4. Effect of Buffalo milk addition on physico-chemical characteristics, yield, coagulation time and texture of camel milk cheese

Buffalo Milk (%)	pH	Acidity (%)	Protein (%)	Fat (%)	Moisture (%)	Yield (%)	Coagulation Time (min)	Texture (N)
0	5.23±0.033 [c]	0.92±0.006 [c]	15.55±0.33	15.33±0.33 [b]	71.00±0.58 [a]	20.33±0.33 [c]	37.67±1.45 [a]	5.0±0.35 [d]
10	5.07±0.033 [b]	0.96±0.003 [b]	16.02±0.33	16.83±0.44 [a]	68.50±0.29 [b]	22.00±0.58 [c]	31.13±1.25 [b]	5.6±0.30 [c]
20	5.03±0.033 [b]	0.96±0.003 [b]	16.67±0.33	17.00±0.29 [a]	66.67±0.33 [c]	25.00±0.58B	28.25±1.02 [c]	6.2±0.25 [b]
30	4.87±0.033 [a]	1.03±0.003 [a]	17.33±0.43	17.87±0.47 [a]	65.67±0.33 [c]	27.33±0.33 [a]	20.28±0.88 [d]	6.8±0.50 [a]

Values are the means of triplicate measurements; [a,b,c,d] Mean values in the same column with different superscripts are different (P<0.05).

Conclusion

It is concluded from the results that camel milk cheese can be prepared effectively by pasteurizing the milk at 65°C for 30 min and changing the pH to 5.5 and addition of $CaCl_2$ to 0.06 %. The cheese quality can further be improved when 10% buffalo milk is blended with camel milk.

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