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Full Length Research Paper

Optimization of camel milk coagulum formation and consumer preference

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ABSTRACT

Studies carried out on camel milk showed that during coagulation only flocs could be obtained with no firm coagulum. The objective of this study was therefore to improve camel milk coagulum formation through addition of stabilizers and evaluate how stabilized fermented camel milks compares with the fermented cow milks. Samples for the study were pooled fresh camel milk and pooled fresh cow milk. The treatments for the tests were; camel milk, camel milk with 0.4 % gelatin, camel milk with 0.8 % gelatin, camel milk with 2 % corn starch, camel milk with 0.8 % gelatin combined with 2 % corn starch and cow milk. Samples for coagulum formation tests were acidified with 1.6 % Gluco-δ-lactone (GDL) and incubated at 25°C for 24 hours and those for consumer preference tests were inoculated with 3 % yoghurt starter culture and 3 % mesophilic starter culture for yoghurt and mesophilic fermented milks respectively. The responses were; acid development in pH, product flow in seconds for viscosity and degree of syneresis (whey separation) in ml for coagulum formation tests and degree of consumer preference in hedonic rating scales for consumer preference test. The study established that the viscosity and the rate of syneresis of the milk gels are significantly different at ($p \leq 0.05$), with the cow milk having the highest viscosity followed by the camel milk stabilized with gelatin and starch. On the rate of syneresis, camel milk stabilized with gelatin and starch exhibited the lowest rate of syneresis. Consumer preference test on yoghurt showed that there was no significant difference at ($p \leq 0.05$), in preference between yoghurt from camel milk stabilized with gelatin and starch and yoghurt from cow milk. The consumer preference for mesophilic fermented milks was found to be significantly different at ($p \leq 0.05$).

Keywords: Coagulum, stabilizers, starter cultures, syneresis, viscosity, hedonic rating.

INTRODUCTION

In pastoral societies, milk is traditionally consumed mostly in the form of fermented milk as the only means of preserving milk under warm conditions (Farah, *et al*., 2004). According to Farah (1996) pastoral communities allow camel milk to ferment naturally at ambient temperature and without prior heat treatment until it turns sour with the resulting fermented milk product known as "*Susa*" among the Somali community. Due to the spontaneous nature of the fermentation, this traditional method results in a product with varying flavour and is often of poor hygienic quality. Compared with fermented cow milk, the consistency of fermented camel milk was found to be thin. These authors further reported that during fermentation of camel milk, with two commercial starter cultures, a flocculant precipitate was formed rather than a coagulum.

The studies by (Farah and Bachmann, 1987; Ramet, 1987; Mehaia *et al*., 1988 and Mohammed and Larson-Raznikiewiz, 1989), on enzymatic coagulation of camel milk, found that during coagulation only flocs could be obtained with no firm coagulum.

Heshim and Khalil (2004) reported that camel milk has antibacterial properties that cause problems during fermentation. Their study indicated that camel milk coagulum is a fragile, heterogeneous curd structure which fails to gel with lactic acid. Jumah *et al*., (2001) compared the rheological properties of curd during gelation process of yoghurt and they found that ovine milk had the highest viscosity, followed by caprine, bovine and camel milk exhibiting the least. They attributed these differences to the chemical composition of milk, especially total solids and protein content. According to Farah, (1996), camel milk has lower total solids content than cow milk, with casein protein content of between 1.9 and 2.3 % compared to cow milk of between 2.8 and 3.2 % and serum proteins content of between 0.5 and 1.0 % and 0.5 and 0.9 % respectively.

According to van den Berg (1988), the International Dairy Federation (IDF) defines fermented milk as products prepared from milk (whole, partly or fully skimmed, concentrated, or reconstituted from partly or fully skimmed milk powder) homogenized or not, pasteurized or sterilized and fermented by specific micro-organisms. According to Driessen and Puhan (1988) quality requirements of fermented milks include; high level of viable counts of starter cultures, good organoleptic properties such as, mild-acid taste, smooth appearance and good texture.

Kessler (1981) demonstrated that addition of gelatin or starch to separated milk increases the firmness of the coagulum and the viscosity of stirred yoghurt but only gelatin reduces or prevents syneresis. Rheology is the study of the deformation of materials, subjected to applied forces (Lewis, 1986). According to this author, fluids will flow under the influence of forces whereas solids will stretch, buckle, or break. Materials which exhibit both types of properties are referred to as viscoelastic. Thus they show elastic properties of a solid when they are deformed by stress and recover their original shape after removal of stress. They also show viscous properties of a liquid, such as flow when stressed. Fermented milks, which are basically of two types, i.e. set and stirred products, exhibit viscoelastic properties. Yolande (1988) reported that set yoghurt is essentially a viscoelastic solid, i.e. the elastic component is predominant, although a viscous component is also present. On the other hand, stirred yoghurt is principally a viscoelastic liquid, i.e. the viscous component is predominant, although an elastic component is also present. Manufacture of fermented milks that are free from defects in body, consistency and syneresis is a problem in the dairy industry (Modler *et al*., 1983). In determining the above mentioned physical quality characteristics in the final product, objective methods are used to analyze texture in the case of the set type products, viscosity for stirred products and syneresis for both types of products as reviewed by Bianchi-Salvadori and Zambrini (1988).

Stabilizers which include binding, gelling and thickening agents, are hydrophilic compounds which are dispersed in solution as colloids, hence their designation as hydrocolloids (Lindsay, 1985). Hydrocolloids generally act by hydrating the solvent and swelling and the degree of swelling depends on the strength of the interaction forces between the macromolecule, e.g. straight chain polysaccharides require more energy to have them separated in order to enable water penetrate through as reflected in their solubilization or gelatinization temperatures. They are mostly branched, long chain molecules, which are able to form a network with each other or with other molecules existing in the emulsion or suspension (Kessler, 1981). Once they are swollen and have attained full solubillization they undergo structural arrangements where the molecules at one or more locations interact in a crystalline manner with similar neighbouring molecules, excluding the solvent from these crystalline junction zones. These intermolecular associations give a gel with a three dimensional network with the solvent molecules dispersed throughout. The strength of the gel depends on the strength of the junction zones that hold the entire structure together (Whistler and Daniel, 1985). Some stabilizers form junction zones, others may not form any but instead solubilize resulting in thickening without gelation (Lindsay 1985).

They are used in the manufacture of yoghurt to prevent whey separation of the product when permitted by national legislation (Puhan, 1988). According to this author, it is advisable where stabilizers are to be used for the first time, to perform laboratory trials which simulate factory conditions before the stabilizers are introduced into the manufacturing process. IDF (1988) recommends different types of stabilizers, for single or mixed use in fermented milk.

The objective of this study was to determine how camel milk coagulation properties can be improved so that the fermented camel milks can be more acceptable to consumers who are more used to fermented milks from cow milk.

MATERIALS AND METHODS

Milk sampling

Fresh camel milk used in this study was obtained from whole pooled herd milk from Egerton University Chemeron Field Station in Baringo County. For comparison, bulk cow milk was obtained from Egerton University Dairy Processing Plant. The samples were all California Mastitis Test (CMT) negative with resazurin disc reading of six (6).

Milk gelling process

Milk samples were gelled by acidification process through hydrolysis by Gluco-δ-lactone (GDL; Sigma Chemicals

Co. St. Louis USA). This was used in order to have consistency in the level of acidification as opposed to use of starter culture. The method described by Arshad (1991) was used where 1.6 % w/v GDL was added to milk samples and incubated for 24 hours at 25 °C to achieve the final pH lower than 4.6, the iso-electric point of caseins. After incubation, samples were stirred and stored at 10 ºC for 24 hours before carrying out syneresis and viscosity tests.
The trials were carried out in quadruplicate using gelatin and corn starch at 0.8 % and 2 % respectively. The stabilizers were all warm soluble type as recommended by IDF (1988).

Fermented milk manufacture

Stabilized fermented camel milk was manufactured according the procedure described by Rasic and Kurmann, 1978 to produce products on which consumer preference tests were carried out with fermented cow milk as the control.
Mesophilic aromatic culture (Freeze-dried direct vat set (DVS), CHN-22; Chr Hansen's Lab. Copenhagen, Denmark) and thermophilic lactic acid culture, type yoghurt (Freeze-dried DVS, YC-X11 Yo-Flex; Chr Hansen's Lab. Copenhagen, Denmark) were used to ferment camel milk with 0, 0.8 gelatin, 2 % corn starch, a combination of 0.8 gelatin and 2 % corn starch and cow milk. During the manufacture, the products were monitored for acid development until they attained an average acidity of 0.9 % lactic acid which is considered normal for fermented cow milks.

Viscosity

Viscosity was measured by a cup-type viscometer where 100 ml of gelled product was poured into the cup with the bottom outlet hole blocked. The hole was then opened and a stop-watch started. The time, in seconds, taken to empty the cup was converted into viscosity values.

Syneresis

A measure of susceptibility to syneresis was obtained by centrifugation of aliquots of 10 ml gelled milk. The milk was allowed to gel in test tubes and kept under cold storage at 10 °C for 24 hours and then subjected to centrifugation at 3000 rpm for 5 minutes. This procedure is a slight modification of the procedure by Harwalker and Kalab (1983). The degree of susceptibility of products to syneresis is measured by the volume of supernatant obtained with the higher volume of the supernatant indicating greater susceptibility to syneresis.

Consumer preference

Starter culture fermented milk samples were coded and presented to a consumer panel to assess their preference using hedonic rating procedure on a five points scale i.e. like very much (2 points), like (1 point) neither like nor dislike (0 points) dislike (-1points) and dislike very much (–2 points) as described by O'mahony (1986). A panel of 29 consumers of fermented milks were randomly selected and asked to taste the products for their acceptability. The tasting was replicated two times.

Statistical analysis

A completely randomized design was used in the study. The treatments for coagulum formation test were pooled fresh camel milk, pooled fresh camel milk with 0.4 % gelatin, pooled fresh camel milk with 2 % corn starch, pooled fresh camel milk with 0.8 % gelatin combined with 2 % corn starch and pooled fresh cow milk. All samples were acidified with 1.6 % GDL; the responses were acid development in pH, viscosity in product flow in seconds and degree of syneresis (whey separation) in ml. All treatments were performed in quadruplicate.

The treatments for consumer preference were pooled fresh camel milk, pooled fresh camel milk with 0.8 % gelatin, pooled fresh camel milk with 2 % corn starch, pooled fresh camel milk with 0.8 % gelatin combined with 2 % corn starch and pooled fresh cow milk. All samples were inoculated with 3 % yoghurt starter culture and 3 % mesophilic starter culture for yoghurt and mesophilic fermented milks respectively; the response was degree of consumer preference in hedonic rating scales.

The data were analyzed using General Linear Model (GLM) Statistical analysis system (SAS) version 6.12 statistical package (1989) to compute the analysis of variance (ANOVA) and means separated by least significance difference (LSD).

RESULTS AND DISCUSSION

The gel formation by acidulation of camel and cow milks using gluco-δ-lactone (GDL) varied with the type of milk. A comparison of the ease with which coagulum formation occurred between these milks is shown in Table 1. It indicated that although the level of acidity in both camel and cow milks was reduced to pH below iso-electric point of caseins of pH 4.6 after 24 hours of incubation, camel milk with and without stabilizers did not form a coagulum while cow milk with and without stabilizers formed a coagulum.

When the level of gelatin was increased from 0.4 to 0.8 % the camel milk formed a thick and smooth coagulum which became more firm during 24 hours of

Table 1. Physical properties of acidified milk gels with 0.4 % gelatin. (n = 4)

Samples	pH after 24 hours of incubation	Coagulum formation
Raw camel milk	4.3	No coagulum formation
Pasteurized camel milk	4.3	No coagulum formation
Pasteurized camel milk + 0.4 % gelatin	4.3	No coagulum formation
Pasteurized cows' milk	4.3	Coagulum formed
Pasteurized cows' milk + 0.4 % gelatin	4.3	Firm coagulum formed

Table 2. Physical properties of milk gels stabilized by gelatin and starch. (n = 4)

Samples	pH after 24 hours of incubation	Viscosity (seconds)	Syneresis (ml)
Camel milk	4.2	21	5.8
Camel milk + 0.8% gelatin	3.9	38	4.3
Camel milk + 2 % corn starch	4.1	27	4.2
Camel milk + 0.8 % gelatin + 2 % Corn starch	4.2	82	0.0
Cow milk	4.3	122	0.0

Table 3. Viscosity and syneresis of acidified cow and camel milk gels. (n = 4)

Sample	Viscosity (seconds)	syneresis (ml)
Cow milk	122.33^{a}	0.70^{a}
Camel milk with 0.8% gelatin & 2 % Starch	82.33^{b}	0.00^{b}
Camel milk with 0.8 % gelatin	38.33^{c}	0.70^{a}
Camel milk with 2 % starch	27.00^{d}	4.33^{c}
Camel milk	21.00^{e}	5.60^{d}

*Mean values in the same column with the same letter are not significantly different at $\alpha \leq 0.05$

cold storage. Results presented in Table 2 show that an increase in gelatin level from 0.4 to 0.8 % initiated coagulum formation and enabled measurement of viscosity and syneresis of camel milk gels.

It is also evident from the results that combining a gelling and thickening agent, gelatin and corn starch respectively, significantly improved the viscosity and reduced the syneresis tendency of the gels. Addition of a thickener alone caused coagulum formation but did not improve the viscosity or reduce the degree of syneresis of the gels while the use of 0.8 % gelatin alone improved the viscosity.

Statistical Analysis

Statistical analysis of viscosity, syneresis and consumer acceptability are presented in Tables 3 and 4. The viscosity of the milk gels is significantly different at ($p \leq 0.05$), with the cow milk having the highest viscosity followed by the camel milk stabilized with gelatin and corn starch. The rate of syneresis of the milk gels was also significantly different at ($p \leq 0.05$), with camel milk stabilized with gelatin and starch exhibiting the lowest rate of syneresis.

The consumer preference tests on yoghurt showed that there was no significant difference at ($p \leq 0.05$), in preference between yoghurt from camel milk stabilized with gelatin and corn starch as compared to yoghurt from cow milk. However, yoghurt from camel milk stabilized with gelatin and corn starch was significantly different from camel milk yoghurt where both stabilizers were not used. The consumer preference for mesophilic fermented milks was found to be significantly different at ($p \leq 0.05$).

Table 4. Consumer acceptability hedonic rating scores for fermented camel and cow milks. (n = 2).

Sample	Yoghurt	Mesophilic (Mala) fermented milk
Cow milk	0.9483^{a*}	1.2414^{a}
Camel milk with 0.8% gelatin & 2 % Starch	0.6897^{a}	0.3966^{b}
Camel milk with 0.8 % gelatin	-0.0517^{b}	0.0172^{c}
Camel milk with 2 % starch	0.1207^{b}	-0.4655^{d}
Camel milk	-0.0690^{b}	-0.8793^{e}

*Mean values in the same column with the same letter are not significantly different at $\alpha \leq 0.05$.

Results on coagulum formation using 0.4 % gelatin which is the highest IDF recommended level for cow milk, showed that only cow milk formed a coagulum. Camel milk formed a coagulum after the level of gelatin was increased to 0.8 %. Other studies showed that camel milk on fermentation only formed flocs but not a coagulum. Work by Hashim and Khalil (2004) showed that the use of hydrocolloids namely, gelatin, sodium alginate and calcium chloride improved yoghurt texture. These authors used 1 % gelatin. The findings of the current study are consistent with those of the above authors, because the gels which had gelatin and corn starch as gelling and thickening agents, respectively had the highest viscosity with no syneresis.

Increased gelatin concentrations resulted in increased intermolecular association, leading to stronger gels which subsequently increased the product viscosity. At the concentration of 0.8 % gelatin, and 2 % corn starch, syneresis was drastically reduced, which may be attributed to a better gel reformation. As Cheftel *et al*. (1985) reported, there is a greater probability of intermolecular contacts and easier gel formation at increased concentrations of gelatin. Viscosity was low in gels formed with either gelatin or corn starch alone. At these concentrations gelatin improved the gelation but intermolecular associations were too weak to improve the viscosity. This may be explained by the fact that the diameter of the dispersed particles in the reformed gels was too small and intermolecular interactions too weak to increase the product viscosity (Cheftel *et al*., 1985).

Corn starch on the other hand produced low viscosity and high syneresis because it could not initiate any gelation and therefore no gels were reformed to undergo intermolecular interactions responsible for increasing viscosity. If any flocs were formed they were too small and intermolecular interactions too weak to increase the product viscosity.

The study showed that a combination of gelling and thickening agents improve the product texture in that there is initiation of coagulum formation and because of solubilization of the gelling agent, there is greater intermolecular interactions, which improve viscosity and also hold the gels together reducing syneresis. Gelatin gives a strong gel because it forms strong junction zones that hold the entire structure together.

The results of this study also indicate that gelatin would serve both as a thickener and gelling agent when higher levels are used while corn starch would only serve as a thickener and therefore requires combining it with a gelling agent in order to reduce syneresis.

Studies on the rheological and microscopic characteristics of the camel milk have shown that its coagulum is a fragile, heterogenous curd structure, which fails to gel with lactic acid cultures. These findings are similar to those of Hashim and Khalil, (2004). These authors found that the use of stabilizers with an increase in milk total solids improved the texture of yoghurt made from camel milk.

After improving the rheological properties of fermented camel milk, it was necessary to find out whether it was more acceptable to potential consumers. Hashim and Khalil (2004) used hydrocolloids to improve rheological properties of yoghurt and went further to show that after improvement in rheology, the product was acceptable to potential consumers. Farah *et al*., (1990) also improved the fermentation of the traditional cultured camel milk (susa) by using mesophilic starter cultures and subjected it to sensory evaluation to asses its acceptability by potential consumers. In the current study, the results showed that a combination of a gelling and thickening agent gives a gel of acceptable rheological properties. Yoghurt and mesophilic fermented milk were subjected to sensory evaluation to assess their preference. The response from a consumer panel showed that yoghurt from camel milk with improved textural properties is just as good as cow milk yoghurt. The hedonic rating method was used in this assessment.

Camel milk has for a long time been a product exclusively consumed by pastoral communities. It is evident from the response of the panellists that fermented camel milk has a potential for being marketed to and consumed by non-pastoralists if its rheology is improved.

Compared to yoghurt from cow milk, camel milk yoghurt stabilized with gelatin and corn starch was not significantly different. Mesophilic fermented camel milk was rated second to mesophilic fermented cow milk with the recommendation that it should be sweetened and flavoured

CONCLUSION

The results in the study indicated that for camel milk to form a coagulum, it requires the addition of both gelling and thickening agents to initiate coagulum formation, improve viscosity, facilitate gel reformation and avoid syneresis. The study also showed that rheologically improved fermented camel milk is just as preferred to consumers as fermented cow milk.

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