Effects of somatic cell counts on the physicochemical and rheological properties of yoghurt made from sheep's milk

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In the present work, yoghurts were made from sheep's milk with two different somatic cell count (SCC), at low (200,000 cells mL^{-1}) and high (750,000 cells mL^{-1}) levels. The characteristics of the final product were analyzed for pH, acidity, protein, total solids, fat, synersis, WHC and apparent viscosity. Samples were analyzed on days 1, 7 and 14 after production of yoghurts. The SCC had no significant effect on acidity or pH of the yoghurt ($p<0.05$). No effect ($p<0.05$) of milk SCC was observed on total solids and fat content of the yoghurt after 24). Low SCC yoghurt also had higher protein content ($p<0.05$). Viscosity of high SCC yoghurt was higher than the low SCC yoghurt on days 1, 7 and 14 of storage. The flow properties also showed that the low SCC yoghurt was softer than yoghurt from milk with higher SCC.

Keywords: Somatic cell count, Yoghurt, Sheep's milk, apparent viscosity

1 INTRODUCTION

All milk contains some level of somatic cell counts (SCC). When there is bacterial infection, tissue damage, or other inflammation processes affecting the mammary tissue the number of SCC in milk increases dramatically [1-2]. Mastitis induces changes in milk that influence dairy product quality [3]. SCC has some effects on yoghurt compositions [4]. The effect of SCC in sheep milk on the properties of yoghurt has not yet been studied. Thus the aim of the present work was to investigate the effect of SCC on the physicochemical and rheological properties of yoghurt made from sheep's milk.

2 MATERIALS AND METHODS

2.1 Manufacture of yoghurts

Milk with two SCC was collected: < 200,000 and > 750,000 cells mL^{-1} and standardized (20% total solids) by the addition of skim milk powder. The standardized milks were pasteurized at 65°C for 30 min and cooled to 37°C. The pasteurized milk was inoculated with a commercial yoghurt culture comprised of *Lactobacillus delbrueckii* subsp *bulgaricus* and *Streptococcus thermophilus* (Chr. Hansen_s Laboratory, Horsholm, Denmark). Inoculated milk (150 mL) were poured into plastic containers, which were covered with lids and incubated at 45°C until the pH had decreased to about 4.5. The containers were then transferred to refrigerator at 4°C to cool the product and to terminate acid development. Some of the samples were analyzed after 24 h, while the remaining samples were stored cool (4°C) for 14 days before examination.

2.2 Chemical analyses of yoghurt

The yoghurts were analyzed for pH (pH-meter, Metrohm, AG, Switzerland), titratable acidity using the Dornic method (after mixing 10 g of yoghurt with an equal mass of distilled water, fat (Gerber method; British Standards Institution 1955), lactose (IDF 1974) and total solids (IDF 1991). All analyses were carried out on six yoghurts for each of the SCCs studied.

2.3 Rheological measurements

Rheological measurements were carried out using a rotational viscometer (Bohlin Model Visco 88, Bohlin Instruments, UK) equipped with C30 measuring spindles and a heating circulator (Julabo, Model F12-MC, Julabo Labortechnik, Germany). For each test, approximately 15-25 ml sample was transferred to sample compartment (bob and cup) following by 3 minutes pre-shearing at 50 s^{-1} to obtain uniform solution. The instrument was programmed to set temperature of 25 ºC and equilibrate for 10 min followed by one-cycle shear in which the shear rate was increased linearly from 0 to 300 s^{-1} in 3 min. Herschel–Bulkley equation was found to be an adequate model to describe the flow behavior of the stirred yoghurt. Flow behavior was described by the fitting of the Herschel–Bulkley) model to experimental data (shear stress-shear rate):

$$\tau = \tau_0 + k\dot{\gamma}^n \quad (1)$$

Where τ is the shear stress (Pa); ($\dot{\gamma}$) is the shear rate (s^{-1}); k is the consistency coefficients (Pa s^n); n is the flow behavior index (dimensionless); and τ_0 is the yield point (Pa.s).

2.4 Statistical analysis

The data on chemical composition and textural attributes were analyzed by one-way analysis of variance (ANOVA), means were compared by the Duncan's multiple range test at the significance level α = 0.05. Linear regression was also used to investigate relationships among measured all parameters.

3 RESULTS AND DISCUSSION

3.1. Impact of SCC on yoghurt composition

The properties of yoghurts produced from milk of each SCC category are shown in Table 1.

Table 1: Effect of somatic cell count on sheep's milk composition used in the manufacture of yoghurt

Yoghurt properties	SCC of milk (× 1000 mL^{-1})	
	< 200	> 750
Acidity	16.2 ± 1.12 [a]	15.1 ± 1.23 [b]
pH	6.5 ± 0.06 [b]	6.7 ± 0.02 [a]
Fat (%,w/w)	5.28 ± 1.28 [a]	4.76 ± 1.14 [b]
Protein (%,w/w)	5.21 ± 0.34 [a]	5.73 ± 0.47 [a]
Lactose (%,w/w)	5.13 ± 0.18 [a]	4.65 ± 0.22 [b]
Total solids(%,w/w)	16.79 ± 0.93 [a]	16.29 ± 1.03 [b]

3.2. Flow behavior

Tables 2 present the rheological parameters of the yoghurt from sheep`s milk containing different SCC.

Table 2: Effect of somatic cell counts on yield stress (τ_0), consistency coefficient (k) and flow behavior yoghurt index (n) of made from sheep`s milk.

SCC	Time	τ_0	k	n
High				
	1	50.34±1.5	11.90±0.52	0.14±0.03
	7	52.00±1.1	12.47±0.75	0.18±0.01
	14	52.23±1.2	14.10±0.48	0.23±0.04
Low				
	1	51.73±0.9	11.50±0.72	0.17±0.03
	7	52.77±0.7	12.10±0.42	0.20±0.02
	14	54.50±0.6	13.52±0.21	0.27±0.01

From the industrial point of view, all of the rheological models were considered suitable to represent the rheological data of the sheep`s milk yoghurt due to the high values of the determination coefficient. However the Herschel-Bulkley model was chosen to fit the experimental data in this work due to its characteristics of being a full model that could describe all the rheological parameters (yield stress, consistency coefficient and flow behaviour index) well, when compared to the Power Law model (two parameters model) that does not present the yield stress term. For the Herschel-Bulkley model, the determination coefficient (R^2) values were 0.99 thus these results showed a good fit for the Herschel-Bulkley model.

Yield stress is an important quality control parameter in industrial processes, particularly for comparing the overall characteristics of products made on different production lines [5]. Stirred yoghurt containing SCC behaved as pseudoplastic fluids exhibiting yield stress. For high SCC yoghurt, the yield stress varied between 50.34 and 52.23 Pa while the magnitude was much higher for low SCC yoghurt (51.73 to 54.50 Pa). The yield point (τ_0) was also positively related to the storage day; however, this trend was not apparent for yoghurt with low SCC.

4 CONCLUSIONS

This study confirms that high levels of SCC in sheep milk effects on properties of yoghurt. The changes have detrimental effects economically, and while research results are sometimes conflicting, the degree of effects reported for sheep milk seems to have somewhat lesser repercussions on yoghurt quality than those reported for cow milk. There is a great need for further research to determine carefully the threshold at which SCC affects sheep milk characteristics, and the quality of related dairy products. In addition to animal species, technological processes have a great impact on the definition of such thresholds. Assessment of somatic cells conditions on the farm needs to be provided. Adequate sanitary control of herds and flocks would be the best guarantee to prevent the occurrence of pathogens and to ensure the imperative requirement of food safety of dairy products from small ruminants.

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