DOI: 10.1002/jsfa.2190

# The development of a goat's milk yogurt

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**Abstract: This study sought to establish conditions suitable for a small-scale yogurt process using goat's milk and to examine the physicochemical properties (pH, titratable acidity, solids-not-fat (SNF), viscosity, texture) and organoleptic acceptability (preference by Filipino panellists) of the resultant product. Goat's milk was concentrated by heating (80 °C, 1 h), which resulted in an increase in SNF from 85 to 110 $g\,kg^{-1}$. To further improve the curd of goat's milk yogurt, two hydrocolloids were used: carrageenan (1.5 and 3 $g\,l^{-1}$) and pectin (50 $g\,l^{-1}$). The addition of dehydrated pineapple and banana cubes (50 and 100 $g\,l^{-1}$) in a sundae-style formulation increased the SNF by an additional 2.5% and produced a curd that was firmer than the control, plain set yogurt. The use of carrageenan appeared to be a convenient way of controlling product viscosity. In terms of product preference and firmness the fruit-flavoured sundae-style yogurts were ranked higher by sensory panellists.**


**Keywords:** goat milk; goat yogurt; viscosity; firmness; solids-not-fat (SNF)

## INTRODUCTION

In the last decade there has been increasing interest in the functional properties of foods. Yogurt, potentially containing beneficial microflora from lactic acid fermentation, offers the consumer more than just the conventional nutrients of a dairy product. In addition, yogurt has both reduced lactose levels and active lactase enzymes which may allow lactose-intolerant individuals to consume moderate amounts of this dairy product.[1] Although yogurt made from cow's milk is conventional, yogurt products have been prepared with varying success from ovine and caprine milk.

Yogurt gels are particulate structures composed mainly of casein, and in general these continuously connected strands of protein produce a heterogeneous three-dimensional gel network that holds water.[2] The total solids-not-fat (SNF) content of the original milk plays a crucial role in facilitating the development of this physical network. Methods to increase milk solids include the addition of powdered milk solids, water-binding stabilisers such as pectin[3] and carrageenan,[4] dehydrated apples and peaches,[5,6] and evaporation of the milk.[2]

Goat's milk differs from bovine milk in a number of ways. It has more free amino acids[2] and its unique casein precipitates more readily and into finer particles[7] than cow's milk. The fat globules and micelles are smaller in goat's milk than in cow's milk.[8] The higher amounts of short-chain fatty acids (caproic, caprylic and capric acids) present are partially responsible for the distinct flavour of goat's milk.[9] Goat's milk readily picks up a slightly rancid and musky flavour and aroma,[10] which is a challenge in using goat's milk fresh or in a processed form. Previous researchers[11–14] have investigated various aspects of goat's milk yogurt with varying degrees of success.

The present study extends the previous work and combines both processing techniques (evaporation) and product reformulation (hydrocolloids, dehydrated fruit) in attempts to achieve a goat's milk yogurt that was typical of a yogurt product and, at the same time, was accepted by members of Filipino origin. Eight yogurt formulations were tested: (a) plain set yogurt (control), (b) plain set yogurt with 1.5 and 3 $g\,l^{-1}$ carrageenan, (c) sundae-style yogurt with 50 and 100 $g\,l^{-1}$ dehydrated pineapple cubes, (d) sundae-style yogurt with 50 and 100 $g\,l^{-1}$ dehydrated banana cubes and (e) stirred yogurt with 50 $g\,l^{-1}$ commercial pectin. The quality of the yogurt products was evaluated based on their physicochemical characteristics (pH, titratable acidity, SNF, apparent viscosity, firmness) and organoleptic acceptability.

## EXPERIMENTAL

### Raw materials

Raw goat's milk was obtained from an inspected goat dairy in Canada (Fox Hollow Dairy Limited, Middle Musquodoboit, Nova Scotia, Canada). The milk was a composite from a goat herd which had 425 animals of

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Contract/grant sponsor: Canadian International Development Agency (CIDA) Island Sustainability Livelihood and Equity Program (ISLE)
(*Received 30 June 2003; revised version received 30 November 2004; accepted 27 January 2005*)
Published online 4 May 2005

mixed Alpine, Nubian, Saanen and Lamanche breeds. Raw milk that was not immediately processed into yogurt was pasteurised at 72 °C for 15 s and stored at 1–2 °C until yogurt preparation for no more than 24 h. This was necessary as facilities did not permit simultaneous preparation of all yogurt formulations.

Fresh pineapples (Del Monte brand) in the rare-ripe stage were cubed (1.3 $cm^3$), blanched (100 °C, 3 min) and drained. Osmotic dehydration was performed using a 1:1 (w/w) cubes/sugar ratio and allowing contact for 24 h. Excess surface sugar was lightly rinsed off with a spray of water and the cubes were dehydrated (Berron Food Dehydrator Model 60; Vancouver, Canada) for 14 h at a dry bulb temperature of 65 °C. Fresh green mini-bananas (Ecuadorian Chiquita bananas) were peeled, cut into 1.3 cm slices and dipped in ascorbic acid solution (10 $g\,l^{-1}$) to minimise enzymatic browning. The banana slices were then combined in a 1:1 (w/w) ratio with sugar and osmotic dehydration was performed as above, except that the time required in the dehydrator was only 8–10 h for this fruit. The stabilisers used in the study were composed of carrageenan (FMC dairy grade) and commercial fruit pectin (Bernardin brand). Commercial mixed starter culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* in freeze-dried form (Yoghourmet brand, Lyo-San Industries, Lachute, Canada) was used to ferment the goat's milk.

Six replicates of each yogurt formulation were prepared from one pooled batch of goat's milk and subjected to physicochemical and organoleptic analyses. A randomised complete block design was employed where the blocking factor was the batch of goat's milk used ($n = 2$).

## Chemical analysis of raw materials

Each container of raw goat's milk was analysed for pH and titratable acidity before pasteurisation. The SNF content of the goat's milk was analysed at several stages in the yogurt process (raw, after pasteurisation and after pasteurization/evaporation) as a means of following the concentration of the milk. The phosphatase test was used to confirm the adequacy of pasteurisation. All analyses were performed in triplicate.

## General processing method (plain set yogurt)

*Preparation of milk base*

To pasteurise and concentrate the milk, 2 l of goat's milk was placed in an open stainless steel stockpot and heated at 80 °C for 1 h. The milk was stirred continuously to distribute the heat uniformly and enhance evaporation. The milk was then cooled to the incubation temperature (43 °C) by immersing the stockpot in cold water.

*Fermentation*

A 5 g aliquot of starter culture was added to ferment 1 l of pasteurised/evaporated milk. The inoculated milk (0.1 l) was then filled into individual plastic transparent cups. A modified roasting pan with water was used as a water bath incubator. The cups were placed on top of a grill laid at the bottom of the pan, and the fermentation was conducted (4 h, 43 °C). To halt the activity of the starter micro-organisms, the yogurt was transferred into a refrigerator set at 1–2 °C.

## Yogurt product formulations

For the plain set yogurt with carrageenan the hydrocolloid (1.5 and 3 $g\,l^{-1}$) was added to the pasteurised/evaporated milk and stirred to dissolve before the starter culture was added. In the case of the pineapple- and banana-flavoured sundae-style yogurts the concentrated milk base was sweetened with sucrose (50 $g\,l^{-1}$) before adding the starter culture. The dried fruit cubes were weighed into the containers prior to the addition of the sweetened inoculated milk (50 and 100 $g\,l^{-1}$). To prepare the stirred-type yogurt, the coagulum of plain set yogurt was stirred and a pectin slurry composed of 5 g of powdered fruit pectin, 0.1 g of citric acid and 20 ml of water was mixed into 100 ml of the yogurt.

## Physicochemical analysis

The pH, titratable acidity and SNF content (Mojonnier infrared method) of the yogurt products were determined after 24 h of refrigerated storage. The firmness of the yogurt products was measured.[11] A Lloyd (Mississauga, Canada) tensile testing machine fitted with a Magnus Taylor (Mississauga, Canada) probe modified with a plastic disc (2.5 cm diameter, 1.3 cm thickness) at the end was used. The compression was done with a force of 5 N, moving at a speed of 10 $mm\,s^{-1}$ until the probe penetrated the yogurt to a depth of 5 mm. The apparent viscosity of the yogurt products was measured with a Fisher McMichael (Toronto, Canada) rotational viscometer. Refrigerated samples were tested with a certified No 22 wire using a 3 cm sample depth. All analyses were performed in a minimum of three replicates.

A mass balance on the dehydrated fruit cubes used in the sundae-formulations was performed. Twenty-four hours after preparation the fruit pieces were separated from the yogurt base by a strainer, lightly rinsed and shaken to remove rinse water. By determining the moisture content of the resultant fruit pieces, the water taken up from each yogurt formulation was calculated.

## Organoleptic analysis

Preference testing was conducted with a 15-member sensory panel. To meet the objectives of developing a yogurt-like product that met Filipino food and cultural norms, panellists were drawn from a somewhat limited pool of Filipino immigrants residing in Nova Scotia; this constraint accounted for the uncharacteristically small number of panellists. The samples were given to the panellists following a balanced, randomised order of presentation.

## Statistical analysis

The data were analysed statistically using the Statistical Analysis System (SAS Institute, Cary, NC, USA). Specifically, the general linear model (GLM) was employed at a significance level of $\alpha = 0.05$. Where significant differences were detected between means, Tukey's mean test was used to identify significant differences between individual means.

## RESULTS AND DISCUSSION

### Process development

Averaged over nine batches, the pasteurisation/evaporation process resulted in a 35.7 g kg$^{-1}$ increase in the total solids content of the milk base, which represented a 3.57% increase in total solids (Table 1). This followed the recommendation that an increase in total solids content of more than 2.5% is required if goat's milk yogurt is to have a viscosity comparable to that of cow's milk yogurt.[15] The mean level of milk solids (155 g kg$^{-1}$) obtained by the pasteurisation/evaporation process employed for nine batches of milk in this study was in fact higher than the values obtained by Abrahamsen and Holmen[15] for milk concentrated by vacuum evaporation (141 g kg$^{-1}$), ultrafiltration (142 g kg$^{-1}$), reverse osmosis (139 g kg$^{-1}$) and addition of milk powder (142 g kg$^{-1}$). Under the milk evaporation conditions described, the concentration of the milk base did not inhibit the starter activity at these levels, nor did the use of various hygroscopic ingredients (sugar, pectin, carrageenan, dried fruit cubes). As the goal was to produce an acceptable yogurt product, there was no attempt in the present study to separate or understand the effects of the change in milk solids content from the effects of added ingredients.

### Chemical characteristics of yogurt formulations

The pH of the control yogurt (4.25; Table 2) was lower than the range of 4.44–4.49 found for the only other goat's milk yogurt formulation reported in the known literature.[16] In the present study the goat's milk was concentrated before fermentation, while Olvido[16] did not employ this processing technique; the resultant concentration of the natural acids in the milk and/or the nature and activity of the starter culture used in this study may account for the difference in pH. The pH of the banana-based yogurts (4.44–4.53) was significantly higher ($\alpha = 0.05$) than that of the control goat's milk yogurt. The addition of the higher level of dehydrated fruit pieces resulted in a significantly higher SNF content in the banana yogurt product but was not accompanied by any significant increase in pH (Table 2). This may indicate that there was no measurable suppression of the starter activity by the higher quantity of milk solids present in these formulations. The natural acidity of pineapple products may account for the 0.2–0.3 pH unit reduction recorded for the two yogurt formulations prepared using dehydrated pineapple (1PA and 2PA).

The sundae-style yogurts prepared using the dehydrated fruit pieces had final pH levels in the range of 3.92–4.53; the pH of the plain yogurt product was 4.25. Only the goat's milk yogurts prepared with the hydrocolloids exhibited a product pH below 3.9, which may be a result of greater starter activity under the conditions of these formulations. In the case of the pectin formulation the citric acid used as part of the pectin suspension and pH adjustment would have contributed to the higher acidity. Interestingly, using a level of carrageenan that was fourfold higher, the other Filipino study[16] did not demonstrate a similar low pH. The titratable acidity values (Table 2) showed trends similar to those reported for product pH.

The SNF content of the heated milk was 109.3 $\pm$ 1.9 g kg$^{-1}$. After fermentation the yogurt bases prepared with the dehydrated banana and pineapple

**Table 1.** Total solids of nine batches (1–9) of pasteurised and pasteurised/evaporated goat's milk and % increase resulting from evaporation

| | Total milk solids (g kg$^{-1}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Pasteurised | 123.7$^b$ | 123.2$^b$ | 123.3$^b$ | 118.6$^b$ | 119.2$^b$ | 118.2$^b$ | 118.0$^b$ | 117.8$^b$ | 117.3$^b$ |
| Pasteurised/evaporated | 162.7$^a$ | 160.7$^a$ | 162.4$^a$ | 154.6$^a$ | 154.0$^a$ | 154.0$^a$ | 149.4$^a$ | 151.3$^a$ | 151.7$^a$ |
| % increase in total solids | 3.90$^c$ | 3.75$^c$ | 3.91$^c$ | 3.60$^c$ | 3.48$^c$ | 3.58$^c$ | 3.14$^c$ | 3.35$^c$ | 3.44$^c$ |

$^{a-c}$ Means within a row with the same letter are not significantly different at $\alpha = 0.05$.

**Table 2.** pH, titratable acidity and solids-non-fat (SNF) content of yogurt products

| | Formulation | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Plain | 1PA | 2PA | 1BA | 2BA | PE | 1CA | 2CA |
| pH | 4.25 | 3.92 | 4.06 | 4.44 | 4.53 | 3.74 | 3.76 | 3.75 |
| Titratable acidity (g l$^{-1}$) | 0.118 | 0.123 | 0.112 | 0.085 | 0.092 | 0.136 | 0.124 | 0.122 |
| SNF (g kg$^{-1}$) | 110.2$^d$ | 165.7$^c$ | 169.0$^c$ | 174.4$^b$ | 189.6$^a$ | 114.8$^d$ | 112.1$^d$ | 111.1$^d$ |

1PA = 50 g l$^{-1}$ pineapple; 2PA = 100 g l$^{-1}$ pineapple; 1BA = 50 g l$^{-1}$ banana; 2BA = 100 g l$^{-1}$ banana; PE = 50 g l$^{-1}$ pectin; 1CA = 1.5 g l$^{-1}$ carrageenan; 2CA = 3 g l$^{-1}$ carrageenan. Titratable acidity expressed as lactic acid.
$^{a-d}$ Means with the same letter are not significantly different at $\alpha = 0.05$.

all had significantly higher SNF levels than the original milk (Table 2). Previous researchers[5,6] attributed a similar effect of dried apples and peaches to a rehydration of the fruit pieces. The dehydrated banana and pineapple cubes were found to partially regain their original size and shape and absorbed, on average, their own dehydrated weight from the sundae-style formulations. For instance, the higher level of dehydrated banana cubes, added at a rate of $100\,g\,l^{-1}$, increased to $201.9\,g\,l^{-1}$ after being in contact with the sundae-style formulation for 24 h. A similar increase in mass of the fruit pieces was observed with the pineapple. This fruit rehydration was presumably responsible for the relative increase in the SNF of the dairy portion of the product. The plain set (control) yogurt as well as the yogurt prepared with the three hydrocolloid treatments had SNF contents ranging from 110.2 to $114.8\,g\,kg^{-1}$; this was not substantially increased from the $109.3\,g\,kg^{-1}$ SNF content of the original milk.

## Physical attributes of yogurt formulations

If a viscous product is the primary desired attribute, use of the carrageenan hydrocolloid would result in the formulation of choice (Fig 1). While there was no discernible viscosity difference between the 1.5 and $3\,g\,l^{-1}$ carrageenan formulations, the higher level of hydrocolloid was accompanied by the production of a firmer yogurt product ($\alpha \leq 0.05$) without an appreciably higher acidity (Table 2). Based on these physical attributes, the carrageenan treatment shows promise. In spite of the references in the literature to the important relationship between SNF and gel strength,[2] the carrageenan formulation may have resulted in the formation of a viscous network in spite of the low SNF content, which was lower than that of the control (Fig 1, Table 2). The higher viscosity of the carrageenan treatments was, however, not directly translated into maximum product firmness (Fig 2).

A lower quantity of carrageenan than reported previously[16] was needed to increase the viscosity of plain set yogurt when concentrated goat's milk was used. A level of $1.5\,g\,l^{-1}$ carrageenan, as compared with $6.8\,g\,l^{-1}$,[16] was sufficient to produce a thick yogurt comparable to that of a conventional yogurt product.

In fact, the fruit-based sundae-style yogurts were found to have firmer textures on the surface of the dairy phase of the product than the other formulations examined in this study. The firmness of the yogurts prepared with dehydrated fruit cubes was superior (Fig 2) and did exhibit the expected relationship with the higher SNF content.[2] Testing only the firmness of the product's dairy component (to a depth of 1.3 cm) removed any potential interference from the presence of the fruit at the bottom of the container. These treatments did not score as high with respect to apparent viscosity as the carrageenan formulations did.

The low viscosity of the pectin (PE) treatment would suggest that, based on the convention that yogurt should normally be viscous, the pectin stirred-style yogurt was not overly promising. This low viscosity was more likely a result of the stirring during the final stages of preparation than of the inability of pectin to form a viscous system in goat's milk, as pectin is used successfully in conventional yogurt. Alternatively, the preliminary studies on the pectin slurry may not have adequately optimised the pH (citric acid) and sugar to allow the high methoxy pectin content to reach its gelling potential. Of course, if the objective is to develop a semi-liquid yogurt beverage product, the pectin formulation may show promise.

## Product preference scores

The sensory preference scores indicated that the pineapple-based yogurts were most preferred ($\alpha \leq 0.05$) followed by the banana-flavoured products.

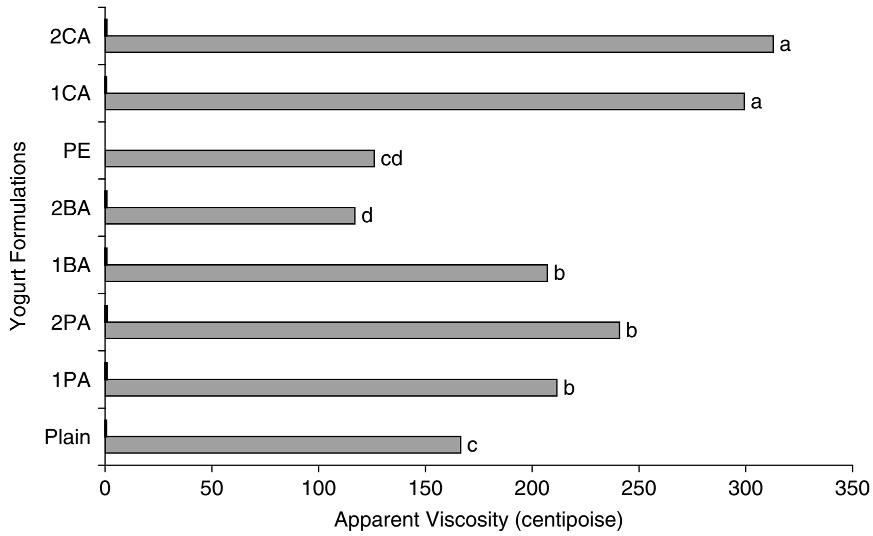


**Figure 1.** Apparent viscosity of yogurt products. 1PA = $50\,g\,l^{-1}$ pineapple; 2PA = $100\,g\,l^{-1}$ pineapple; 1BA = $50\,g\,l^{-1}$ banana; 2BA = $100\,g\,l^{-1}$ banana; PE = $50\,g\,l^{-1}$ pectin; 1CA = $1.5\,g\,l^{-1}$ carrageenan; 2CA = $3\,g\,l^{-1}$ carrageenan. [a–d]Means with the same letter are not significantly different at $\alpha = 0.05$.

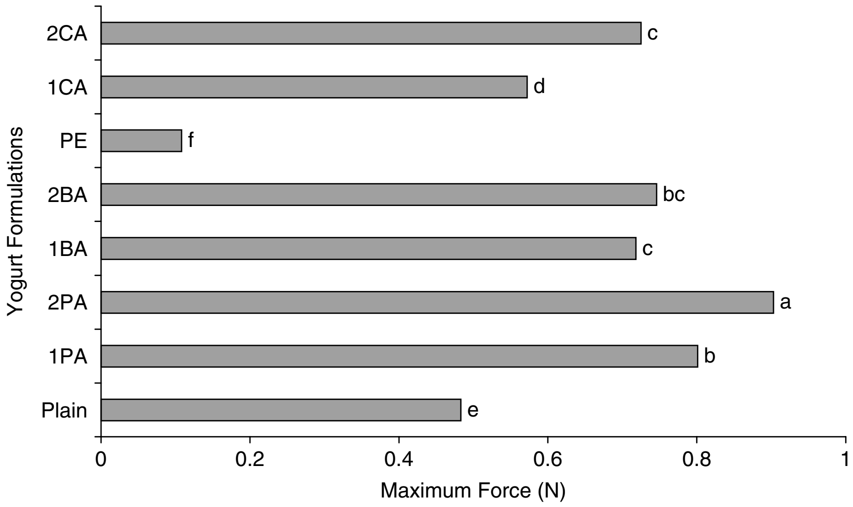


**Figure 2.** Firmness of yogurt products. 1PA = 50 g $l^{-1}$ pineapple; 2PA = 100 g $l^{-1}$ pineapple; 1BA = 50 g $l^{-1}$ banana; 2BA = 100 g $l^{-1}$ banana; PE = 50 g $l^{-1}$ pectin; 1CA = 1.5 g $l^{-1}$ carrageenan; 2CA = 3 g $l^{-1}$ carrageenan. $^{a-f}$Means with the same letter are not significantly different at $\alpha = 0.05$.

The pectin formulation (PE) and the plain yogurt did not find favour amongst the Filipino panellists used in this study. The yogurt products formulated with the two levels of carrageenan (CA) were moderately acceptable based on the results of the preference test ranking scores.

## CONCLUSION

This work has shown that there is a possibility for the development of a simple process for making yogurt using goat's milk. The thermal process used was suitable for concentrating the milk SNF to 110 g $kg^{-1}$, which still allowed growth of the starter culture and permitted the development of a viscous yogurt product. The sundae-style yogurt incorporating osmotically dehydrated fruit was successful in further enhancing the physical properties of the finished product and was preferred by the sensory panellists.

## ACKNOWLEDGEMENT

The authors are very grateful to the Canadian International Development Agency (CIDA) Island Sustainability Livelihood and Equity Program (ISLE) for funding this research.

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