

## Composition, sensory evaluation and melting properties of caprine ice cream produced with different fat sources

Composição, avaliação sensorial e propriedades de derretimento do sorvete de leite de cabra produzido a partir de diferentes fontes de gordura

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### ABSTRACT

This study evaluated the composition (soluble and total solids, pH, titratable acidity, protein, fat, ash, total reducing sugar), the sensory attributes (appearance, odor, consistency and taste) and the melting behavior of two experimental formulations of caprine ice cream made with two different fat sources, hydrogenated vegetable fat (F1) and a trans-free fat replacer (F2). Soluble and total solids, fat and total reducing sugar of the ice cream samples were statistically different ( $p < 0.05$ ). The sensory results showed high sensory acceptability index (AI) ( $> 70\%$ ) for both formulations, with the exception of the flavour attribute of F1 formulation, which had AI equal to 62.041%. In the meltdown test, the F2 group melted faster than the F1 formulation. The results demonstrated that the source of fat used in the ice cream mix directly interferes with the melting characteristics, acceptance rate and physicochemical composition of ice cream.

**Key words.** goat milk, ice cream, sensory acceptance, meltdown test.

### RESUMO

O presente estudo avaliou a composição (sólidos totais e solúveis, pH, acidez total titulável, proteína, gordura, cinzas, açúcares totais), os atributos sensoriais (aparência, odor, consistência e sabor) e o comportamento, durante o derretimento, de duas formulações experimentais de sorvete caprino elaborados com duas diferentes fontes de gordura, gordura vegetal hidrogenada (F1) e um substituto de gordura livre de ácidos graxos trans (F2). Os teores de sólidos totais e solúveis, gordura e açúcares totais das amostras de sorvete apresentaram diferenças estatisticamente significantes ( $p < 0,05$ ). Os resultados sensoriais mostram elevado índice de aceitação (IA) sensorial ( $> 70\%$ ) para ambas as formulações, com exceção do atributo sabor da formulação F1 que apresentou IA de 62,041%. No teste de derretimento, o grupo F2 derreteu mais rápido que a formulação F1. Os resultados demonstraram também que o tipo de gordura usada interfere diretamente nas características de derretimento, nível de aceitação sensorial e composição do sorvete caprino.

**Palavras-chave.** leite de cabra, sorvete, aceitação sensorial, teste de derretimento.

## INTRODUCTION

Nowadays, the Brazilian dairy industry is based on bovine milk products. Despite that, caprine milk has been historically produced in significant amounts in Northeastern Brazil, where nearly 90% of the national herd is located<sup>1</sup>. Despite the larger volume available for cow milk, the production and marketing of goat milk and its products is a niche in the dairy industry sector, since the uniqueness of goat milk can be powerful in promoting dairy goats as a valuable complement to the dairy cow industry<sup>2,3</sup>. It is also believed that goat milk and its processed products are greatly useful as functional foods, especially for those who suffer from cow milk allergy<sup>4,5</sup>. Other important attributes of goat milk are its higher digestibility, distinct rheological characteristics and higher buffering capacity<sup>2,6,7</sup>.

Despite its nutritional and technological significance, few attempts have been made to systematically study the use of caprine milk for production of dairy products other than cheese and yoghurt<sup>8</sup>. Ice cream, for example, is one of the many popular dairy products that could be successfully produced with goat milk. It is a product with high nutritional value, but in some countries ice cream is still identified by consumers simply as a dessert and its consumption is highly seasonal<sup>9</sup>.

One of the particularities of ice cream is its unique structure. The foamy structure of ice cream, in which air bubbles are covered by ice crystals, individual or partially coalesced fat globules and lactose crystals, can be classified as a colloidal complex of high consistency<sup>10</sup>. Fat behavior during stabilization, freezing and aeration has an important influence on the structure of ice cream. The fat crystals, when well homogenized, allow for the desired incorporation of air cells during whipping, maintaining a smooth texture<sup>11,12</sup>. Fat contributes to the melting resistance of ice cream, promote softness and body and have the property of absorbing and retaining flavors<sup>13</sup>. The types of fat commonly used in ice cream formulations are hydrogenated fats. More recently fat-free formulations have been used as a result of a trend towards increased consumption of reduced fat products and one area where this potential exists is the production of fat reduced ice cream<sup>14</sup>.

Based on that, this study aimed to develop passion fruit ice cream using caprine milk by testing two experimental groups of ice cream samples made with different fat sources, hydrogenated vegetable fat and a trans-free fat replacer. Each experimental group

was characterized with respect to physicochemical composition and sensory acceptance. Melting behavior was also evaluated and the differences found between the two types of ice cream produced are discussed.

## MATERIALS AND METHODS

### Ice cream preparation

For each sample, an approximately 6.50 kg batch of ice cream mix was prepared and ingredients were added to the mixing tank (Brasfrio, Brazil) in the following order: 4.50 kg of reconstituted goat milk (Caprilat, Brazil), 0.32 kg of corn syrup (Corn Products Brazil, Brazil) and 0.80 kg of granular sugar. The mixture was heated to 40°C and mixed for 20 minutes. After that, it was added 0.14 kg of hydrogenated fat for group F1 (Duas Rodas Industrial, Brazil) or 0.40 kg of Selecta Cream fat replacer for group F2 (Duas Rodas Industrial, Brazil), 0.56 kg of stabilizer-emulsifier (Duas Rodas industrial, Brazil) and 0.20 kg of passion fruit flavoring (Duas Rodas Industrial, Brazil). The ice cream mixes were pasteurized in a batch pasteurizer (Etiel, Brazil) at 70°C for 30 minutes, cooled, transferred to a refrigerated holding tank (Brasfrio, Brazil) and aged for 20 hours at 4°C. The aged mixes were then frozen using a batch freezer (PHB 80/100, Brasfrio, Brazil), with an adjusted 100% overrun, packaged into 500 mL polyethylene containers (Copobras, Brazil), hardened and stored in a freezer (Electrolux, Brazil) at -18°C for 24 hours. Three batches of the two formulations were prepared in different days and ice cream samples were collected for triplicate analysis.

### Analytical methods

For the pH measurement, about 10g ice cream samples were dissolved in 90 ml distilled water. After homogenization, the pH was measured using a pH meter (Hanna Instruments, USA)<sup>15</sup>. The acidity was determined by titration with a sodium hydroxide N/9 standard solution, using a 1% alcoholic phenolphthalein solution as an indicator<sup>16</sup>. The results were expressed as % lactic acid. The analyses of soluble solids were carried out using a model Smart1 refractometer (Atago, Japan), while total solids<sup>16</sup> and ash content<sup>15</sup> were analyzed using gravimetric determinations<sup>14</sup>. Protein analyses were performed using the Kjeldahl method<sup>15</sup>. The levels of total reducing sugars were determined by the 3,5-dinitrosalicylic acid (DNS) method<sup>17</sup>. Fat content was determined according to O'Dell and Watrous<sup>18</sup> in which the Gerber butyrometer method for cream was used.

### Sensory test

The sensory analyses were performed with 90 untrained panelists using a structured 9-point hedonic scale ranging from 1 (disliked it very much) to 9 (liked it very much). Ice cream was evaluated for appearance, odor, consistency and taste. Approximately 15g of each sample was placed in a 50ml disposable container which was coded with three-digit numbers, sealed and kept in a thermal box to maintain the samples' temperature (approx. 10°C). The acceptability index (AI) was calculated according to the equation  $AI (\%) = Y \times 100/Z$ , where Y = the average score obtained for the product, and Z = the maximum score given to the product. It was considered that for a product to be sensory accepted, the AI must be equal to or greater than 70%<sup>19</sup>.

### Meltdown test

Meltdown properties evaluation was based on Innocente et al<sup>20</sup>. Samples of 100 g were placed on a wire screen fitted in a funnel that drained into a graduated cylinder. The sample was allowed to melt in a controlled temperature room at  $22 \pm 0.5^\circ\text{C}$ . The melted volume was determined at 5-minute intervals and plotted as a function of time.

### Statistical analysis

One-way analysis of variance (one-way Anova) was conducted using Statistica Software. A significance level of 5% was adopted for all comparisons. Tukey's test was used to determine the significant difference between different treatments.

## RESULTS AND DISCUSSION

### Composition

**Table 1** shows the results for formulations F1 and F2 of passion fruit ice cream made with goat milk. The composition of the ice cream samples statistically differed ( $p < 0.05$ ) for soluble and total solids, fat and total reducing sugars. The pH values were lower when compared to Davidson et al<sup>21</sup> and Akalin and Erişir<sup>22</sup>, who respectively found pH ranging from 5.60 and 5.47 for fermented probiotic ice cream. It is important to emphasize that the use of powdered milk can act as a product standardization factor to minimize the expected variations in milk composition due to the breed, diet, lactation stage, health and physiology of the animal.

The main role of the fat substitute is to efficiently replace the hydrogenated vegetable fat. Nevertheless, usually

it has high solid, carbohydrate and protein contents<sup>23</sup>, a fact which explains the higher solids, total reducing sugar and protein content observed for the F2 formulation.

**Table 1.** Physicochemical and sensory results of goat milk ice cream samples

| Physicochemical analysis       | F1                          | F2                          |                         |        |
|--------------------------------|-----------------------------|-----------------------------|-------------------------|--------|
| pH                             | 4.423 ± 0.010 <sup>a</sup>  | 4.654 ± 0.03 <sup>a</sup>   |                         |        |
| Acidity, % lactic acid         | 0.840 ± 0.061 <sup>a</sup>  | 0.872 ± 0.02 <sup>a</sup>   |                         |        |
| Soluble solids, °Brix          | 33.282 ± 0.252 <sup>a</sup> | 39.520 ± 0.612 <sup>b</sup> |                         |        |
| Total solids, %                | 33.340 ± 0.012 <sup>a</sup> | 36.243 ± 0.06 <sup>b</sup>  |                         |        |
| Protein, %                     | 2.664 ± 0.130 <sup>a</sup>  | 3.024 ± 0.32 <sup>a</sup>   |                         |        |
| Fat, %                         | 5.331 ± 0.570 <sup>b</sup>  | 2.331 ± 0.570 <sup>a</sup>  |                         |        |
| Ash, %                         | 0.722 ± 0.021 <sup>a</sup>  | 0.761 ± 0.032 <sup>a</sup>  |                         |        |
| Total reducing sugars (g/100g) | 10.752 ± 0.563 <sup>a</sup> | 14.042 ± 0.95 <sup>b</sup>  |                         |        |
| Sensory analysis               | F1                          | F2                          | F1                      | F2     |
|                                | Average score               |                             | Acceptance Index (AI),% |        |
| Appearance                     | 6.960 ± 1.162 <sup>a</sup>  | 7.044 ± 1.082 <sup>a</sup>  | 77.310                  | 78.243 |
| Odor                           | 6.381 ± 1.55 <sup>a</sup>   | 7.631 ± 1.202 <sup>b</sup>  | 70.832                  | 84.722 |
| Consistency                    | 7.172 ± 1.230 <sup>a</sup>  | 6.832 ± 1.34 <sup>a</sup>   | 79.630                  | 75.931 |
| Taste                          | 5.583 ± 1.932 <sup>a</sup>  | 6.883 ± 2.25 <sup>b</sup>   | 62.041                  | 76.390 |

The values are mean ± standard deviation

<sup>a,b</sup>Values in the same line followed by different superscripts are significantly different ( $p < 0.05$ )

### Sensory analyses

Sensory quality is most closely linked to the choice of food products. This evaluation technique can be applied from designing a new food product to the standardization and evaluation of the reference of product quality. When it comes to sensory analyses, ice cream has its own particularities like the ideal temperature of degustation ranging from 10 until 12°C and a maximum of six samples for capture and absorption of sensory interactions by judges. In addition to that, during consumption it undergoes phase changes from solid to liquid<sup>24</sup>. All these facts make ice cream a complex food system to be sensory evaluated.

The values of the sensory analysis are displayed in **Table 1**. Similarly to what was observed for the physical chemical results, the experimental groups showed marked sensory differences and the average odor and flavor scores were statistically higher ( $p < 0.05$ ) for F2 formulation.

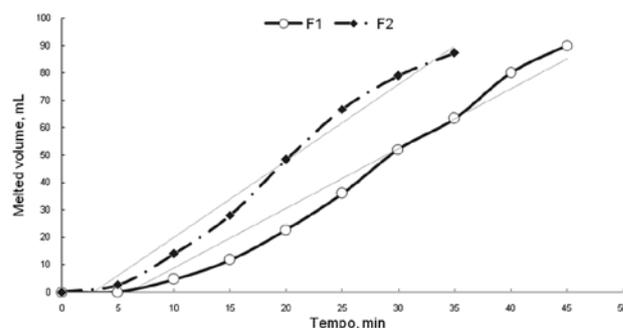
The ice cream made with fat substitute (F2) had acceptance indices (AI) greater than 75% for all attributes considered and it also stood out for its proper creaminess and taste. This can be explained by its higher solids, protein and total reducing sugar content, which could influence the flavor and general impression of the product, with a significant effect on the product's firmness<sup>14</sup>.

It is known that a great deal of flavour compounds is at least partially soluble in fat. Changes in the amount and the type of fat in food may affect the perceived intensity and duration of flavours<sup>24</sup>. Despite that, the sensory scores obtained by F2 formulation suggest that the lower fat content of the samples haven't produced a negative effect on the tested sensory attributes.

### Meltdown test

During the melting of ice cream, two events occur: the melting of ice and the collapse of the stabilized foamy structure. Initially the exterior ice melts and diffuses into the viscous unfrozen serum phase, flowing downwards through the elements – destabilized fat globules, air cells and ice crystals - that form the ice cream structure. The meltdown test evaluates the dripping through the screen on which the ice cream rests, giving some insight about how this frozen structure is organized.

For both groups, after ten minutes the melting curve was practically linear. The formulation markedly influenced the melting speed, a parameter obtained from the slope of the linear regression curves corresponding to the melting curves. The equations for the melting of goat milk ice cream with hydrogenated vegetable fat (F1) ( $y = 2.179x - 12.994$ ;  $r^2 = 0.9602$ ) and goat milk ice cream with fat substitute (F2) ( $y = 2.789x - 8.055$ ;  $r^2 = 0.9779$ ) (**Figure 1**) show that formulation F2 displayed faster melting than F1, in view of the higher value of the curve slope. This may be a consequence of the weakening of the structural network, caused by the lower amount of fat in the formulation. Fat contributes to the melting resistance of ice cream, maintenance of the three-dimensional ice cream network, also contributing to the structure maintenance<sup>25</sup>. The results may infer that the fat replacer created a different ice cream structure giving it a smoother and softer texture.



**Figure 1.** Melting over time of formulations F1(o) and F2(♦) of caprine ice cream

Previously, it was observed that caprine ice cream exhibits a faster melting speed and smoother texture when compared to ice cream made with bovine milk<sup>17</sup>. It is known that the fat globules of goat milk have smaller diameters<sup>26</sup>, which can influence the behavior of ice cream during melting<sup>27</sup>. According to Koxholt et al<sup>28</sup>, fat globules larger than a critical diameter are retained in the foam lamellae, which help to stabilize the foam structure, while smaller fat globules, like those found in caprine milk, flow out of the foam structure. If there are too many of these smaller globules and agglomerates, ice cream is less stable and melts faster.

Parameters such as fat destabilization, ice crystal size and consistency coefficient index affect the melting rate of bovine ice cream<sup>29</sup>. These specific structural relationships still have to be worked out for caprine ice cream.

### CONCLUSION

Caprine ice cream samples made with different fat sources were tested. The composition of ice cream made with hydrogenated fat (F1) and fat replacer (F2) were different for soluble and total solids, fat and reducing sugars ( $p < 0.05$ ). Formulation F2 had higher acceptance indexes and average sensory scores. Besides that, it was observed that the meltdown behavior of the samples was influenced by the type of fat used in the formulation. Results show that ice cream made with fat replacer melted faster when compared with samples formulated with the traditional hydrogenated fat.

Although bovine ice cream manufacture and structural elements have been widely studied, little has been shown for caprine ice cream. Here we investigate important particular attributes for the ice cream made with goat milk, besides showing that the replacement of hydrogenated vegetable fat by trans-free products is a technological alternative for the developments of caprine ice cream.

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