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# Ice creams made from cow's and goat's milks with different fat concentrations: physical-chemical and sensory properties

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**Abstract**

Goat's milk ice cream made with different fat concentrations was compared with cow's milk ice cream. DSC curves indicated typical behavior of the high water content system. The thermal properties, the enthalpy of fusion ($\Delta H_m$) and the amount of water ($w_{uf}$) did not vary with the formulations. For goat's milk ice cream, the viscosity was higher for smaller fat content. Independent of the milk, high fat content promoted greater air incorporation and melting point, indicating a softer and more stable product. Goat's milk ice cream was highly accepted by the consumer with the term "liked it a lot" on the hedonic scale.

**Keywords:** viscosity; milk; fat; DSC; sensory analysis, rheological properties.

**Practical Application:** Goat's milk represents an important alternative to people allergic to cow's milk; however, it is a food little consumed or marketed. Goat's milk could also be used in the production of dairy desserts such as ice cream to enhance its hypoallergenic and nutritional properties.

## 1 Introduction

Goat's and cow's milks have similar compositions; however, goat's milk presents characteristics that make it more digestive, such as a high percentage of short and medium chain fatty acids (Park et al., 2007; Ceballos et al., 2009; Ribeiro & Ribeiro, 2010; Haenlein 2004; Alférez et al., 2003), fat globules smaller than 5 µm (Silanikove et al., 2010; Attaie & Richter, 2000), as well as a distinct alkalinity and larger buffering capacity (Fisberg et al., 1999). Calcium, phosphorus and potassium levels are higher in goat's milk compared to cow's milk (Silanikove et al., 2010), and vitamins A, B1, B12, C and D are present in slightly higher levels in goat's milk (Ribeiro, 1998).

The hypoallergenic property of goat's milk is associated with α-S1 casein. It is a fraction considered to be the main cause of allergy from cow's milk, and it occurs in smaller amounts in goat's milk. Its molecular and antigenic structures are different in the milk of both species (Ceballos et al., 2009; Ribeiro, 1998). Hodgkinson et al. (2018) found that goat's milk caseins presented higher digestibility than cow's milk caseins in an in vitro digestion system that simulated the gastric conditions of children and young adults. Tagliazucchi et al. (2018) also observed higher digestibility in vitro of goat's milk compared to cow's milk. Almaas et al. (2006) found that human proteolytic enzymes degraded goat milk proteins more rapidly than that of cow's milk. Medeiros et al. (2018) verified the antioxidant, antibacterial and antitumor activities in vitro of the whey of goat's milk, indicating the possibility of its use as a functional food.

Given the unique properties of goat's milk, different studies have shown the possibilities of its use in products such as cheeses (Martins et al., 2018; Ramón et al., 2018; Kondyli & Katisiari, 2001; Pitso & Bester 2000), yogurt (Hadjimbei et al., 2020; Silva et al., 2017; Medeiros et al., 2014; Bezerra et al., 2012), dairy drinks (Buriti et al., 2014) and bioactive drinks (Mituniewicz–Małek et al., 2019; Komes et al., 2017). The use of goat's milk to produce ice cream, one of the most popular desserts produced mainly from cow's milk, has also been the subject of some studies. According to Correia et al. (2008), ice creams produced with either cow's or goat's milk presented similar chemical compositions of protein content, lipids, ash and total reducing sugars. There are however some differences between the two. In tests for melting, which are affected by lipid interactions, fat crystallization and fat globule diameter (Granger et al., 2005; Koxholt et al., 2001; Olson et al., 2003), ice cream prepared with goat's milk preserved its structure and shape for longer compared to cow's milk ice cream (Correia et al., 2008). Ice cream from goat's milk maintained texture and sensory quality for eight weeks during storage at -18 °C (McGhee et al., 2015). Açu et al. (2017) produced ice cream with probiotic and functional properties based on goat's milk. Silva et al. (2015) also concluded that goat milk presented technological potential for the production of probiotic ice cream with satisfactory physical-chemical, sensorial and cellular viability.

Considering the properties of goat's milk, the present work aimed at the elaboration of different formulations of ice creams based on goat's or cow's milk in order to compare the nutritional and functional properties as well as sensorial acceptance of final product.

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## 2 Materials and methods

### *2.1 Production of the ice creams*

For each of the raw materials employed (goat's or cow's milks), three chocolate flavored ice cream formulations were made with a different total fat (animal and vegetable) content of 8%, 10% and 12%. All the formulations were in agreement with the norms defined by Brazilian Legislation (Agência Nacional de Vigilância Sanitária, 2003). The mass balance for the correct use of ingredients was done according to Marshall & Arbuckle (1996). The amounts of all the components were: sucrose (13%) (Caravela, Brazil), whole powdered cow's milk (1.23%) (Nestlé), whole powdered goat's milk (1.23%) (Scabra), dehydrated corn glucose (5%) (MOR REX 1940, Corn Products Brasil), guar gum stabiliser (0.2%) (IRX 23337, Colloides Naturels Internacional), emulsifier (0.2%) (MONO-DI HO 52 F-B, Danisco Ltda.), chocolate flavouring (85-238-03-5 Duas Rodas Industrial), caramel dye (Ingredion, Brazil) and chocolate powder (Nestlé).

The components were weighed, mixed and homogenised with whole goat's or cow's milk milk (75.97% for ice cream with 8% of fat; 75.76% for 10% of fat and 74.82% for 12% of fat) in an industrial blender (Metalúrgica Visa Ltda. L015-NR944). A pasteurisation process followed at 70 °C for 30 min, which are conditions equivalent to the time/temperature required to destroy pathogenic microorganisms (Agência Nacional de Vigilância Sanitária, 2003). This mix was placed in a stainless-steel recipient and kept to mature for 16 hours in a cold chamber at 5 °C to promote hydration of the hydrocolloids in the mixture (stabiliser and emulsifier). After maturation, the mixture was beaten for 5 min in a scraped surface heat exchanger (Brasfrio PHB 80/100 SP, Brazil). The processing temperature was -6 °C, and the beat time was 5 min. The finished ice cream was stored in 5 L packages in plastic-lined paper especially made for holding ice cream was held at a temperature of – 25 °C in a horizontal freezer.

The experiments were carried out in duplicate, and the order of preparation was randomised. Samples for the analysis of the mix properties were removed after maturation, and samples for the analysis of the ice cream properties were removed after 24h of storage at −25°C. All the physical-chemical analyses were carried out in triplicate, including the overruns.

### *2.2 Characterizations of ice cream mixes*

#### Rheological behaviour of the ice cream mixes

The rheological properties of the ice cream mixes were studied by determining their flow curves using a Brookfield, model DVIII+ rheometer with a concentric cylinder geometry. These tests used a small sample adaptor (Spindle SC4-18) connected to a thermal bath for different temperatures (2, 3, 4 and 5 °C) with a variation in rotational speed increasing from 150 to 250 rpm and decreasing from 250 to 150 rpm.

#### Thermal properties of ice cream mixes

The mix samples were analysed using a DSC-TA2010 differential scanning calorimeter controlled by a TA5000 module. The samples (~10mg) were weighed using a precision balance (±0.01mg) and placed in hermetic aluminium TA pan and heated between −100 and 100 °C at 10 °C/min in an inert atmosphere (45 mL/min $N_2$). The reference was an empty pan. The DSC cells were frozen by quenching with liquid nitrogen before the analyses.

The glass transition temperature of the maximally freeze-concentrated fraction (Tg') was determined as the point of inflexion on the baseline of the DSC curves, and the melting enthalpy ($\Delta H_m$) was calculated as the area of the endothermal peak (Sobral et al., 2001). These determinations were carried out with the Universal Analysis software V1.7F (TA Instruments).

The amount of unfrozen water ($w_{uf}$) in the samples was calculated from Equation 1 (Oliveira et al., 2005):

$$w_{uf} = x_{wb} - \frac{\Delta H_m}{\lambda} \tag{1}$$

Where $\Delta H_m$ is the ice melting enthalpy, λ is the latent heat of melting of pure water (333.55 $Jg^{-1}$), and $x_{wb}$ is the humidity of the sample (wet basis), determined as in 2.2.

### *2.3 Characterizations of ice creams*

*Protein, total solids and moisture of ice creams*

Considering that there are no reasons for changing the composition from a mix to its ice cream, these characterizations were carried out only for ice creams. Proteins in the ice cream were ascertained using the Kjeldahl method, which determined total organic nitrogen using a 6.38 as conversion factor specifically for milk (Association of Official Analytical Chemists, 1995).

Total solids and moisture contents were determined after drying in an oven at 100 °C. A 5 g aliquot of each ice cream sample was weighed into a pre-weighed flat-bottomed dish and heated in a water bath at 100 °C for 30 minutes, followed by drying in an oven to a constant weight. After establishing the ice cream's dry weight, the moisture content was calculated as the difference between the dry (final) and wet (initial) weights of the sample (Association of Official Analytical Chemists, 1995). All measurements were done in triplicates (mixture and ice cream).

*Measurement of overrun*

The "overrun" measures the incorporation of air during the beating stage of ice cream processing. This incorporation influences product characteristics such as texture, softness, body and size of the ice crystals formed. Overrun was measured from the ratio between the weight of a known volume of the mixture (mix) and the weight of the same volume of ice cream, Equation 2:

$$\text{Overrun} = \frac{\text{mass of ice cream - mass of mix}}{\text{mass of mix}} \tag{2}$$

*Melting behaviour of ice creams*

The analysis of melting was carried out using approximately 70 mL of ice cream stored at –25 °C on a stainless steel screen with a 0.1×0.1mm mesh. Melting occurred at a controlled temperature of 24 °C. The melted ice cream (liquid) that drained off was collected in a 100 mL glass cylinder and measured every 30 min for 2 h. The melting behaviour was obtained graphically from the dripped volume of melted ice cream (mL) as a function of time (min).

*Microbiological analyses*

Total aerobic and coliform counts were carried out using specific analyses for ice creams according to Marshall & Arbuckle (1996). The most probable number method (MPN) of the total coliform, fecal coliform and *E. coli* counts, and the total aerobic mesophilic and psychrotrophic counts were determined according to Silva et al. (1997).

*Sensory analysis*

A sensory panel, which was composed of 102 children of ages 12 to 15 from the city of Pirassununga, Brazil, was used for the sensory analysis of the ice cream samples. This age range was chosen as representing potential consumers, since the product was being developed for children and elderly people allergic to cow's milk. A verbal nine-point hedonic scale was used for the analysis of overall acceptance. Hedonic scales are used to identify greater acceptance of one product in comparison to the others, and this difference is evaluated from the means for acceptance; products presenting means significantly higher than the others ($p \leq 0.05$) are considered as preferred. The tests were carried out in the Laboratory of Sensory Analysis of FZEA/USP, which controlled the test conditions as follows: individuality of judgments, silence, temperature, illumination and control in sample preparation, as well as processing the results quickly.

The panelists received samples coded (with 3 digit numbers) at random and presented on trays together with a glass of water and a score sheet in accordance with the complete block design where the same positioning was repeated the same number of times to avoid any negative effect related to the sample's presentation. The results were statistically analysed using the analysis of variance (ANOVA) and the Tukey means test (SAS v. 8.0).

## 3 Results and discussion

### *3.1 Production of the ice creams*

All ice creams were produced in the same way and stored at –25 °C for 24 h. The characteristics of the ice creams made with different raw materials and fat percentage are presented below.

### *3.2 Characterizations of ice cream mixes*

*Rheological behaviour of the ice cream mixes*

The results of rheological analysis of the mixes were influenced by the raw material for mixes with 8%, 10%, and 12% of fat, respectively (supplementary material). In general, a linear dependence typical of Newtonian behavior was observed between shear stress and the shear rate with little hysteresis. The rheological properties are relevant to the process (Bakshi & Smith, 1984), since in the temperature intervals studied (2, 3, 4 and 5 °C) the mix is pumped from the pasteurisation stage to the maturation stage and then sent to the beating stage.

From the linear regression of the experimental data of shear rate *versus* shear stress (Figures 1, 2 and 3), the viscosity values (angular coefficient of the line fitted to experimental data) of the ice cream mixtures were calculated as a function of milk type (cow or goat), fat concentration and process temperatures (Table 1). For all the ice cream mixes of different formulations and temperatures studied, the viscosities of the mixes prepared with goat's milk were higher than the viscosities of the same ice cream mixes created with cow's milk (supplementary material and Table 1).

Considering the goat's milk mixtures, the highest viscosity was obtained in the formulation with 10% fat at all temperatures analysed; however, the sample with 8 and 12% fat did not present a significant difference for the different temperatures, except at 4 °C (Table 1).

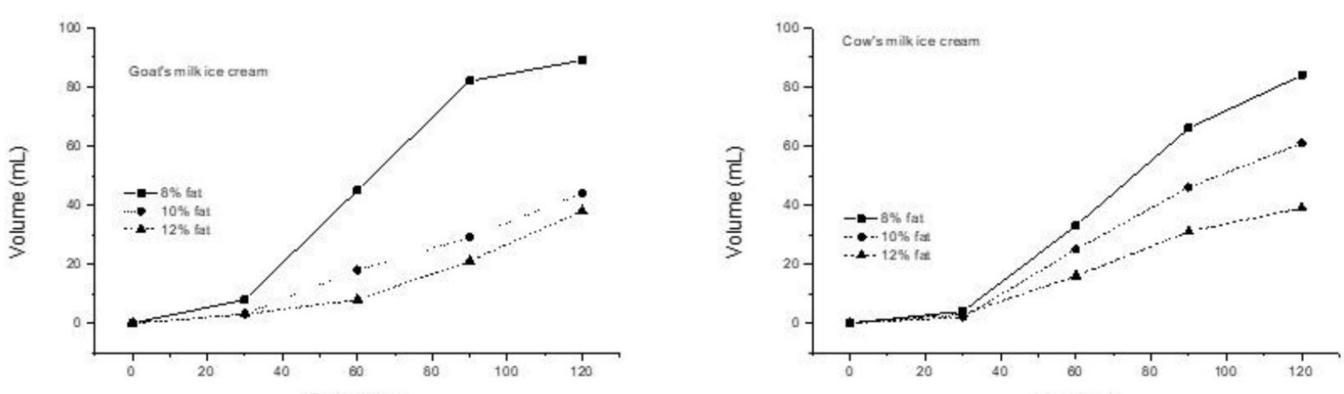


**Figure 1**. Comparison of the melting behaviors of cow's and goat's milk ice creams with variable fat compositions of 8%, 10% and 12%.

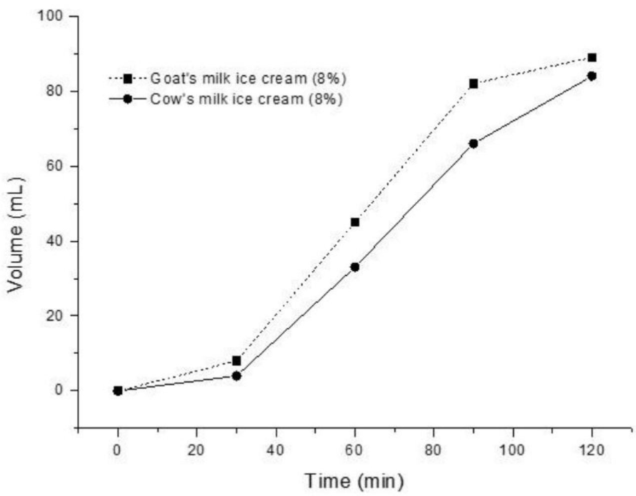


**Figure 2**. Melting rate of the ice creams with 8% fat.

**Table 1**. Viscosity (Poise, D.s/cm$^2$) of the ice cream mixture for different temperatures and fat content.

| Goat's milk | | | |
|---|---|---|---|
| Temperature (°C) | Fat | | |
| | 8% | 10% | 12% |
| 2 | 2.27 ± 0.05$^{aB}$ | 2.69 ± 0.02$^{aA}$ | 2.17 ± 0.02$^{aB}$ |
| 3 | 2.12 ± 0.03$^{bB}$ | 2.43 ± 0.03$^{bA}$ | 2.08 ± 0.03$^{bB}$ |
| 4 | 1.97 ± 0.03$^{cC}$ | 2.38 ± 0.02$^{bA}$ | 2.13 ± 0.03$^{abB}$ |
| 5 | 2.05 ± 0.06$^{bcB}$ | 2.37 ± 0.03$^{bA}$ | 2.02 ± 0.02$^{cB}$ |
| Cow's milk | | | |
| Temperature (°C) | Fat | | |
| | 8% | 10% | 12% |
| 2 | 1.99 ± 0.02$^{aC}$ | 1.52 ± 0.03$^{aD}$ | 1.38 ± 0.01$^{aD}$ |
| 3 | 1.92 ± 0.05$^{aC}$ | 1.45 ± 0.03$^{abD}$ | 1.06 ± 0.04$^{bE}$ |
| 4 | 1.79 ± 0.02$^{bD}$ | 1.42 ± 0.03$^{bE}$ | 0.99 ± 0.02$^{cF}$ |
| 5 | 1.76 ± 0.01$^{bC}$ | 1.28 ± 0.02$^{cD}$ | 0.85 ± 0.02$^{dE}$ |

For lower case letters in the same column: variation of viscosity in goat or cow ice cream as a function of temperature for each fat concentration. For capital letters in the same row: viscosity variation between goat and cow ice cream as a function of fat content for each temperature.

For the cow's milk mixtures, the highest viscosity was found in the formulation containing 8% fat. The viscosity of these mixtures, at the same temperature value, decreased as the amount of fat was increased (Table 1). It can also be concluded that for all the formulations made with cow's or goat's milks, the values for viscosity decreased with increase in temperature.

*Thermal properties of ice cream mixes*

The DSC curves of ice cream mixes were typical for a very moist system, and two phenomena were observed: a glass transition appeared as an inflexion in the baseline, and ice melting in the form of an endothermal peak appeared just after the first phenomenon (supplementary material). The glass transition is less visible than the endothermic peak because of the greater energy variation involved in the second phenomenon (Sobral et al., 2001); it can be better visualised in an amplified scale (supplementary material). This behaviour is common in high water systems such as those typical of ice cream mixes (Goff et al., 1993; Oliveira et al., 2005). Indeed, the ice creams produced in this study presented humidity between 61 and 67% (wb) (Table 2).

According to Goff et al. (1993) and Goff (1994), the glass transition in very moist systems corresponds to $T_g$', which is the glass transition temperature of the maximally freeze-concentrated fraction that tends to be insensible to variation in the moisture content of the sample. For this reason, the Tg' values obtained for the ice cream mixes produced in the present study remained practically constant at around −47 °C irrespective of milk origin. Similarly, the melting temperature of mixes remained almost constant (−1 to 0 °C) (Table 2). These values are higher than the values for Tg' (~ −56 °C) as determined by Oliveira et al. (2005) in a study on *Mangaba* pulp sherbet. This difference can be explained in terms of differences in composition of the dry matter, principally in terms of the soluble solids. It must be remembered that a greater Tg' value could imply greater stability of the ice cream during storage, since the product will be stored under conditions closer to its glass transition (Goff, 1994; Pintor-Jardines et al., 2018).

Conversely, the ice melting enthalpy usually increases with an increase in product humidity (Telis & Sobral, 2002; Oliveira et al., 2005). Although a difference in moisture content ($p \leq 0.05$) was observed between the mixes produced with cow's and goat's milks, no difference ($p > 0.05$) between the values for ice melting enthalpy ($\Delta H_m$) was observed, which varied between 138 and 154 J g$^{-1}$. This same behaviour was observed for the amount of unfrozen water ($p > 0.05$).

The values for $w_{uf}$ calculated in the present study (0.20-0.23 gg$^{-1}$) were higher than the values (< 0.14 gg$^{-1}$) determined by Oliveira et al. (2005) for *Mangaba* pulp sherbet. These results indicate that the amount of energy required to freeze the product ($\Delta H_m$) and the ratio between the product humidity and the amount of unfrozen water ($w_{uf}/x_{mc}$) were independent of the amount of fat added or raw material used; these parameters could not have an influence on processing when these two raw materials were used. Although different raw materials were used, the general results showed no alterations in the behavior of the thermal properties despite the differences in protein content determined between the ice creams (Table 2) and the variations in their fat concentrations. In another study, however, the enthalpy of ice creams made with a low fat concentration presented enthalpy with values lower than presented in this study (Pintor-Jardines et al., 2018).

### *3.3 Characterizations of ice creams*

*Protein, total solids and moisture of ice creams*

As could be expected, there was no difference in protein content ($p > 0.05$) among ice cream samples created from the same raw material because the only variable in composition was the amount of fat added. A comparison of the samples elaborated with different types of milk showed a greater protein content in the goat's milk ice cream ($p \leq 0.05$) (Table 3). The difference in protein content observed in ice cream (Table 3) is related to the variation in protein composition in goat's and cow's milk (Verruck et al., 2019).

**Table 2**. Humidity ($x_{mc}$), melting enthalpy ($\Delta H_m$), unfrozen water content ($w_{uf}$), melting temperature ($T_m$) and glass transition temperature of the maximally freeze-concentrated material ($T_{g'}$) of the ice cream mixes with different fat contents.

| Ice cream | $x_{mc}$ (g g$^{-1}$) | $\Delta H_m$ (J g$^{-1}$) | $W_{uf}$ (g g$^{-1}$) | $W_{uf}$/ $x_{mc}$ (%) | $T_m$ (°C) | $T_{g'}$ (°C) |
|---|---|---|---|---|---|---|
| Goat 8% | 0.622$^c$ | 137.5$^a$ | 0.210$^a$ | 33.72$^a$ | -1.0$^a$ | -47.6$^a$ |
| Goat 10% | 0.645$^b$ | 137.7$^a$ | 0.232$^a$ | 36.01$^a$ | -0.4$^a$ | -46.7$^a$ |
| Goat 12% | 0.623$^c$ | 143.1$^a$ | 0.194$^a$ | 31.14$^a$ | -1.3$^a$ | -46.9$^a$ |
| Cow 8% | 0.646$^b$ | 140.3$^a$ | 0.223$^a$ | 34.62$^a$ | -0.4$^a$ | -46.8$^a$ |
| Cow 10% | 0.614$^c$ | 138.7$^a$ | 0.198$^a$ | 32.31$^a$ | -0.5$^a$ | -46.0$^a$ |
| Cow 12% | 0.667$^a$ | 153.6$^a$ | 0.206$^a$ | 30.92$^a$ | -0.0$^a$ | -47.6$^a$ |

Means in the same column with different letters differed according to the Tukey test ($p \leq 0.05$).

**Table 3**. Protein, total solids content and overrun in the ice creams with different fat concentrations.

| Fat (%) | Protein (g 100 g$^{-1}$) | | Total solids (g 100g$^{-1}$) | | Overrun (%) | |
|---|---|---|---|---|---|---|
| | Cow's Milk | Goat's Milk | Cow's Milk | Goat's Milk | Cow's Milk | Goat's Milk |
| 8 | 3.39$^b$ | 3.83$^{ab}$ | 35.66$^b$ | 37.78$^a$ | 28.29$^a$ | 28.39$^a$ |
| 10 | 3.48$^b$ | 4.49$^a$ | 38.59$^a$ | 35.49$^c$ | 29.40$^a$ | 29.09$^a$ |
| 12 | 3.35$^b$ | 4.29$^a$ | 33.34$^c$ | 37.72$^a$ | 30.47$^a$ | 30.61$^a$ |

Means in the same column with different letters differed according to the Tukey test ($p \leq 0.05$).

The ice creams produced with goat's and cow's milk showed significant variations ($p \leq 0.05$) between the formulations regarding the total solids content. This result, however, did not show a correlation with the different fat contents used in the formulations, since samples with lower fat concentrations and a consequently higher proportion of milk powder in the formulation should have presented higher dry matter concentrations (Table 3).

*Overrun*

The physical structure of ice cream is composed of three phases: liquid, solid and gaseous. In the manufacture of ice cream, incorporating air produces "overrun" or an increased volume of ice cream over the volume of the mixture. The incorporation of air is important because it influences the texture and melting point and consequently the product's quality. The air incorporation or overrun of the ice creams also varies with the concentration of added fat (Silva & Lannes, 2011). The overrun was greater for higher fat concentrations (Table 3), although the variation was not statistically different ($p \leq 0.05$).

The viscosity of the ice cream mix is also considered a factor that could affect air retention and contribute to the final ice cream texture (Yazdi et al., 2020). However, the mixture of ice cream containing goat's milk had higher viscosity compared to the mixture based on cow's milk (Table 1), but no significant difference was observed regarding the overrun of the ice creams (Table 3). In ice cream produced with buffalo milk, Sert et al. (2021) obtained values for the overrun between 19.93 to 45.15%, whose results were mainly affected by the mixing pressure of the mixture.

*Melting behaviour of ice creams*

The curve of ice cream's melting behaviour illustrates the volume of "time-dripping ice cream" under controlled temperature conditions, and it demonstrates the different behaviours of the different fat concentrations (8, 10 and 12%) used**.** Overall, an increase in fat concentration resulted in a decrease in melting point for both cow's and goat's milk ice creams (Figure 1), and it showed that greater fat concentrations contribute to greater product stability. In cow's milk-based ice creams containing 3% fat, Al et al. (2020) observed a melting rate of 36.53 g/60 min, which value is close to the value observed in this work (Figure 2) for the 8% fat concentration. The comparison between these results suggests that factors other than fat content, such as differences in formulation and freezing method, may also affect the ice cream melting rate.

Notably, the ice cream made with goat's milk had the same fat content but demonstrated a lower melting rate than that made with cow's milk (Figure 2). Probably, the difference observed in the melting rate is associated with the fact that the fat in goat's milk is found in the form of small globules that do not aggregate on cooling, as observed in cow's milk (Amigo & Fontecha, 2011).

Differences in melting rate were not observed in the first 30 min or among ice creams made with different raw materials nor those made with different fat contents. This behavior was expected since he melting temperature ($T_m$) of the different mixture formulations did not differ considerably (Table 2). Over time, melting becomes a function of the chemical composition and physical structure that this composition provides.

*Microbiological analyses*

All ice creams studied, regardless the type of milk used, presented counts of microorganisms (Table 4) below the limits defined by the legislation (International Federation of Dairy Products), which fixes a standard limit of $10^5$ CFU/g for the total count, $10^2$ MPN/g for coliforms and the absence of pathogenic microorganisms (Varnam & Sutherland, 1994). These analyses were carried out on the finished products, mainly due to concern about possible contamination and/or proliferation that could occur during the process. Goat's milk is less acid than cow's milk, and considering the long maturation period of 16 h, it was thought that greater microbial proliferation would be observed

**Table 4**. Microbiological analyses of the different formulations of goat and cow's ice creams.

| Fat | Mesophilic (CFU/g) | | Psychrotrophs (CFU/g) | | Coliforms (MPN/g) | |
|---|---|---|---|---|---|---|
| | Cow's milk | Goat's milk | Cow's milk | Goat's milk | Cow's milk | Goat's milk |
| 8% | 1382.5 | 105 | 115 | 155 | 0 | 0 |
| 10% | 125 | 2550 | 0 | 0 | 0 | 0 |
| 12% | 350 | 1875 | 142 | 0 | 0 | 0 |

**Table 5**. Mean acceptance scores for the different formulations of goat's and cow's milk ice creams.

| Fat | Ice cream | |
|---|---|---|
| | Goat's milk | Cow's milk |
| 8 | $8.32^{b}$ | $8.41^{ab}$ |
| 10 | $8.34^{ab}$ | $8.85^{a}$ |
| 12 | $8.44^{ab}$ | $8.39^{ab}$ |

Means with different letters differed according to the Tukey test ($p \leq 0.05$).

in the goat's milk ice creams, but this did not occur (Table 4). Thus, there was no need to reduce the maturation time in the goat's milk ice creams, which might have prejudiced product characteristics.

*Sensory analysis*

In general, all the samples were well accepted since the mean scores were above 8 on the verbal hedonic scale, which signifies consumer appreciation above "liked a lot". Thus the use of the different primary raw materials - goat's and cow's milks - in the formulations of the chocolate ice creams did not influence consumer product acceptance.

The ice cream made with cow's milk containing 10% fat had the best consumer acceptance and was statistically different ($p > 0.05$) from the sample made with goat's milk containing 8% fat (Table 5). The other samples did not present significant variation with respect to consumer preference.

Considering goat's milk ice cream, the 10% and 12% fat formulations had the highest consumer acceptance scores, but did not differ significantly from the 8% fat formulation (Table 5). For cow's milk ice cream, the highest consumer acceptance was obtained in the formulation containing 10% fat, although the difference between grades for different fat contents is not significant. Lucatto et al. (2020) found greater acceptability of yoghurt made from cow's milk (from 6.24 to 6.85) compared to goat's milk yoghurt (from 5.46 to 5.64) and this result was related to consumers' lack of familiarity with goat milk. Hadjimbei et al. (2020) observed greater acceptance of tasters for goat milk yoghurt containing *Pistacia atlantica* resin extracts (85%), when compared to unflavored yoghurt (15%). These results suggest that the chocolate flavor incorporated into goat milk ice cream contributed to the acceptance of tasters (Table 5), possibly masking characteristic goat milk flavors, since both types of ice cream had similar acceptance.

## 4 Conclusions

The different formulations of chocolate flavoured ice creams made with different fat contents and raw materials indicated that, independent of the type of milk used, an increase in fat concentration resulted in greater air incorporation and an increase in product melting point and that larger fat concentrations would make the ice cream softer and simultaneously more stable in respect to its melting qualities. With respect to mix viscosity, it was shown that when the measurements were made at higher temperatures, the mix was less viscous independent of the type of milk used. The viscosity was higher for lower added fat contents in the formulations of chocolate flavoured ice creams made with goat's milk, but for those made with cow's milk the samples with 10% fat were more viscous than those containing 8 and 12% fat, the latter two showing very similar behaviour. It was also determined that although the goat's milk was less acid than he cow's milk, the same process could be used for both raw materials, including the 16h maturation time, since no microbiological proliferation was observed in the goat's milk mixes.

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