Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.41722

Unripe banana biomass as a dairy fat partial replacer in vanilla homemade ice cream

Isabela Gomes CARDOSO[1], Monise Viana ABRANCHES[2], Mayara Carolline Resende SILVA[2], Flávia Beatriz CUSTÓDIO[3], Ingrid Annes PEREIRA[1], Regina Maria FINGER[1], Laís Buriti de BARROS[1], Beatriz do Nascimento Corrêa dos SANTOS[1], Gardênia Márcia Silva Campos MATA[1]*

Abstract

The homemade ice cream formulations produced from the partial replacement of dairy fat with unripe banana biomass (UBB) were elaborated and characterized. Formulations 1, 2 and 3 with 2.6%, 12.5% and 21.9% of reconstituted UBB, respectively in partial replacement of heavy cream were compared to the traditional formulation (0% UBB and 100% of heavy cream). The characterization included: physicochemical, microbiological, and sensory analyses. Fat reduction of at least 22.6% in centesimal composition were noticed among the formulation with UBB ($p < 0.05$). The titratable acidity and meltdown rate of the formulations increased with the addition of UBB and fat reduction. The sensory analysis showed that the preference of the panellists reduced with substitution of cream for UBB. The traditional formulation and formulation 1 were the most preferred. There was no difference in the attributes of overall impression, appearance, creamy texture, color, sweet taste and vanilla flavor between the traditional formulation and formulation 1 in the acceptance test. It was also found that the intention to consume those same formulations was positive. Therefore, the production of ice cream using prebiotic fat replacers are an interesting option to be explored in an attempt to combine sensory acceptance with health benefits.

Keywords: prebiotic; resistant starch; ice cream.

Practical Application: In this study, a homemade vanilla ice cream was developed and could maintain sensory acceptance and technological characteristics with 2.6% of reconstituted unripe banana biomass in partial replacement of dairy fat.

1 Introduction

The perception about the healthiness of foods by consumer is intricate and suggests the influence of several factors (Plasek et al., 2020). On the other hand, researchers have demonstrated changes in the trend towards food consumption by means of healthier food choices (Nielsen, 2021), growth of health food and beverage market (Adomaitis et al., 2017), and a modest increase in the consumption of healthy eating markers (Steele et al., 2020). This entire scenario is associated with a greater demand for more natural foods that have beneficial health properties (Petrescu et al., 2019).

In this context, artisanal and homemade products, similar in terms of small-scale production, often based on traditional family recipes, with low use of technology and machinery, have gained more space, precisely due to this greater concern for less processed, healthy and good quality ingredients and to minimizing the use of food additives (Cirne et al., 2019). In addition, in the case of artisanal products, it is common to establish local consumption relations, bringing consumers and producers together by involving social and environmental issues, which revolve around sustainability, valuing the local product and traceability. Those reasons support the growing appreciation of artisanal or homemade products (Cirne et al., 2019).

Some strategies such as reducing fat consumption and increasing other nutrients, for instance fiber, can be highlighted among others to meet the demand for health benefits (World Health Organization, 2020). Resistant starch is physiologically considered a type of dietary fiber, which can be fermented by the microbiota present in the intestine, promoting the growth of beneficial bacteria in the colon (Zeng et al., 2018). It is a valuable prebiotic ingredient in the development of products that seek to add fiber to their content, which is associated with a reduction in the glycemic response, improvement in the lipid profile and greater response to satiety (Welti-Chanes et al. 2020).

However, fat is an important technological component in the formulation of various foods, as it provides flavor, creaminess, appearance, odor, in addition to softness and juiciness. Ice cream is an example of a product that can be obtained from milk fat and is widely accepted and consumed by the population with a wide range of varieties and flavors (López-Martínez et al., 2021). The use of ice cream as a vehicle for energy and other nutrients has already been proposed for the elderly and patients who are malnourished and/or have difficulty eating (Spence et al., 2019).

When the intention is to encourage fat reduction in diet, fat replacers used as an alternative in ice cream can be of carbohydrate,

Received 06 May., 2022
Accepted 03 Nov., 2022
[1] *Instituto de Alimentação e Nutrição, Centro Multidisciplinar UFRJ-Macaé, Universidade Federal do Rio de Janeiro – UFRJ, Macaé, RJ, Brasil*
[2] *Instituto de Ciências Biológicas e da Saúde, Universidade Federal de Viçosa – UFV, Campus Rio Paranaíba, Rio Paranaíba, MG, Brasil*
[3] *Faculdade de Farmácia, Universidade Federal de Minas Gerais – UFMG, Belo Horizonte, MG, Brasil*
*Corresponding author: camposgard@gmail.com

protein or lipid origin, used alone or as a blend (Akbari et al., 2019; Arslaner & Salik, 2020). Given the thickening characteristic of unripe banana biomass (UBB), due to its high starch content, its use may represent an effective strategy for replacing fat. The gelling and emulsifying properties of UBB provide increased viscosity, solubility, stability and shelf life, reduced recrystallization, and formation of more homogeneous air bubbles (Yangilar, 2015; Amini Khoozani et al., 2019). As unripe banana pulp has little expressive flavor, its use in product formulations including bread, cake, biscuits, pasta, among others, interferes minimally in the sensory aspect (Fida et al., 2020). Its low cost is also noteworthy, considering that the banana is a fruit cultivated on a large scale, widely consumed, and has great economic importance worldwide (Food and Agriculture Organization of the United Nations, 2020). Fruits that are still unripe are rich in flavonoids, among other antioxidants, which act in the protection of the gastric mucosa, in addition to having a significant content of resistant starch (Falcomer et al., 2019).

The use of unsophisticated technologies in the elaboration of artisanal and homemade products facilitates the reproduction by the consumers themselves, in their homes, considering the lesser complexity of the recipes. However, it is interesting that those products have good acceptance and are safe for consumption, especially when the interest is to make them commercial products. For this reason, adequacy and standardization of the product features are desirable. In this sense, the objective of this work was to elaborate and characterize, through proximate composition, physicochemical and sensorial analyses, homemade ice cream formulations made from the partial replacement of dairy fat by UBB.

2 Materials and methods

2.1 Obtaining the unripe banana biomass

The unripe apple bananas (*Musa acuminata* Colla x *Musa balbisiana* Colla, AAB Group) were obtained in a farm localized in Santo Antônio do Pontal, Governador Valadares, Brazil (geographic coordinates: 18º47’03.6” south latitude and 42º08′22.2″ west longitude) and harvested between stages 1 and 2 of ripening, according to the scale of von Loesecke (1950). After washing and sanitizing with 150 ppm chlorine solution, the unpeeled fruits were cooked (2 atm, 120ºC) for 8 min. Following cooling, the bananas were peeled and mashed in a home processor until the formation of a homogeneous purée (unripe banana biomass - UBB). The UBB was portioned and frozen in a domestic freezer at -15 ºC until use.

2.2 Ice cream preparation

The ice creams were formulated according to the information contained in Table 1. In the preparation stage, the condensed milk, whole milk and egg yolks were mixed and cooked at 80 ºC for 11 min and 35 s until obtaining the “yolk cream”. The following mixture was cooling until 55 °C. The egg whites were pasteurized at 55.5 ºC for 3 min and 30 s (Brasil, 2022a) and whipped in a domestic mixer for 2 min and 30 s, at maximum speed to stiff peaks. Then, sugar and heavy cream were added to the whipped egg white and mixed for the same time with each addition of new ingredient. To the traditional formulation (control) the yolk cream was gradually mixed and, finally, the vanilla extract was added.

Table 1. Ice cream formulations.

Ingredients	Formulations			
	Traditional	1	2	3
Milk (%)	26.7	26.0	24.7	23.8
Condensed milk (%)	26.7	26.0	24.8	23.8
Heavy cream - 25% fat (%)	26.5	25.0	18.8	12.0
Egg (%)	14.3	14.6	13.7	13.4
Sugar (%)	4.9	4.7	4.5	4.3
Vanilla extract (%)	1.0	1.0	0.9	0.8
Reconstituted UBB (%)	-	2.6	12.5	21.9

Whereas formulations enriched with UBB, the difference in the preparation method was the inclusion of UBB and reduction of heavy cream. Firstly, the UBB was thawed under refrigeration for a period of 18 h. Then it was reconstituted in warm water at a 1:1 ratio until it formed a viscous biomass, which was then added to the formulations in the step of adding the heavy cream. Lastly, the ice creams were immediately frozen at -15 ºC.

2.3 Centesimal composition and titratable acidity

The moisture content was obtained by drying the sample at 105°C, until constant mass (Instituto Adolfo Lutz, 2008). The ash content was obtained by weighing the incinerated sample in a muffle at 550 °C (Brasil, 2006). Protein was determined as total nitrogen using the microKjeldahl method. The percentage of crude protein was calculated from the conversion factor of 6.25 (Silva & Queiroz, 2002). Fat determination was carried out after acid hydrolysis (4 mol/L HCl and heating for 30 min), followed by filtration and washing with boiling water. After drying, the residue (105°C for 1h), it was extracted with petroleum ether in a soxhlet extractor for 6h (Instituto Adolfo Lutz, 2008). Total carbohydrate was calculated by the difference of 100 and the values of protein, fat, moisture and ash (Instituto Adolfo Lutz, 2008).

The titratable acidity was obtained by titration with a standardized 0.1 mol/L NaOH solution (Instituto Adolfo Lutz, 2008).

2.4 Meltdown rate

Approximately 75 g of ice cream samples were transferred to an apparatus containing a 2 mm diameter wire screen mesh placed on beckers. The ice cream samples were left at room temperature for 60 min and, at 15 min intervals from the first drop, the weights were recorded. Analyzes were performed at least three times (adapted from Smet et al., 2010; Fiol et al., 2017). Time (min) was plotted against the melted portion (wt.%). After exponential transformation to linearize the melt data, the meltdown rate was determined as the slope of the main melting event.

2.5 Microbiological analysis

The analyses were done according to Downes & Ito (2001). Briefly, the presence of *Salmonella* was evaluated on XLD agar (Acumedia, Lansing, USA). Coagulase-positive *Staphylococcus* count was performed on Baird-Parker agar (Kasvi, Curitiba, Brazil). Colonies belonging to the *Enterobacteriaceae* family were counted on VRBG agar (Acumedia, Lansing, USA). All plates were incubated at 35 °C for at least 24 h.

2.6 Sensory analysis

The preference ranking test was based on ordering from the most to the least desirable samples. Acceptance and consumption intention tests were performed using 9-point structured hedonic scale (Dutcosky, 2013; Reis & Minim, 2013). The attributes evaluated in the acceptance test were overall impression, appearance, creamy texture, color, sweet taste, and vanilla flavor.

Considering the acceptance test, the acceptability index was also calculated (adapted from Castro et al., 2007) for each attribute evaluated using the following Equation 1:

$$\text{Acceptability index}\left(\%\right) = \frac{\text{Average score obtained for the product x100}}{\text{Highest score given to the product}} \quad (1)$$

Twenty grams of each sample were distributed according to a balanced complete block design and coded with three random numbers. Mineral water at room temperature was used as an oral cleaning agent. The tests were carried out in an individual sensory-test booth with red light for the ordering test and white light for the acceptance and consumption intention tests.

An total of 135 untrained volunteers composed the team of panellists. In general, the sample included professionals and university students with low consumption of alcoholic beverages and coffee and low frequency of allergies and respiratory diseases, which indicates good condition of organs sensory by most participants. In addition, a more expressive consumption of ice cream among other frozen desserts was observed, which denotes a greater evaluative capacity of the studied food matrix.

2.7 Ethical care

This research was approved by the Human Research Ethics Committee of the Federal University of Viçosa under the protocol number 47012615.0.0000.5153.

2.8 Statistical analysis

Analysis of variance (ANOVA) followed by Tukey's test was applied to the centesimal composition and titratable acidity. The significant difference between ice cream formulations was evaluated according to Christensen et al. (2006) in the preference ranking test. The two-tailed Student's t-test was applied to assess differences between the means of the scores imputed by the panellists to the ice cream formulations in the acceptance and consumption intention tests. Descriptive statistics were also performed.

3 Results and discussion

3.1 Physicochemical characteristics of ice cream formulations

The centesimal composition of the formulations was shown in Table 2. There was a fat significat reduction of at least 22.6%, unlike the total carbohydrates, which showed a significant increase of at least 9.2% among the formulations. The increase in carbohydrate percentage is probably related to the increase in fiber, starch, and resistant starch content in UBB-added formulations.

In addition, there was no significant difference between fat values in formulation 1 and traditional. Possibly the variation of moisture and other components of the ingredients affected more than the inclusion of UBB in this proportion.

There are few studies in the literature about the elaboration of ice cream with UBB. In those studies, the ice creams were prepared with UBB from cooked or dehydrated fruits, with or without peel, in order to enrich the formulations with the resistant starch prebiotic and not necessarily functioning as a partial fat substitute (Yangilar, 2015; Wrobel & Teixeira, 2017; Prashanth et al. al., 2018). The chemical characteristics in terms of nutritional and physicochemical composition were comparatively different from those of the present study as they depend on the variety of fruits and amount of ingredients used. Despite, Aragão et al. (2018) have shown that the partial replacement of fat with UBB could generate a significant reduction of at least 67% in fat content ($p < 0.05$).

The estimation of dietary fiber and resistant starch contents based on theoretical values (Table 2) allowed us to observe a gradual increase of these compounds from the addition of UBB in the formulations. Considering that resistant starch exerts the physiological effect of dietary fiber, the formulation 2 and 3 were

Table 2. Physicochemical characteristic of ice cream formulations (dry basis).

Formulations	Parameter (g/100 g)									
	Moisture*	Total solids*	Non-fat solids*	Ash*	Protein*	Fat*	Carbohy-drates*	Fiber**	Resistant starch**	Titratable acidity***
Traditional	$57.29^{d} \pm 0.09$	$42.71^{a} \pm 0.09$	$18.78^{a} \pm 1.01$	$2.44^{a} \pm 0.25$	$12.36^{a} \pm 0.25$	$23.93^{ab} \pm 0.99$	$61.28^{bc} \pm 1.13$	0.00	0.00	$0.325^{c} \pm 0.017$
1	$58.41^{c} \pm 0.32$	$41.59^{b} \pm 0.32$	$15.54^{bd} \pm 2.15$	$2.44^{a} \pm 0.23$	$12.61^{a} \pm 0.06$	$26.05^{a} \pm 2.47$	$58.90^{c} \pm 1.76$	0.02	2.64	$0.353^{b} \pm 0.008$
2	$60.35^{b} \pm 0.16$	$39.65^{c} \pm 0.15$	$18.13^{bc} \pm 1.27$	$2.04^{a} \pm 0.20$	$12.64^{a} \pm 0.12$	$21.51^{bcd} \pm 1.35$	$63.79^{ab} \pm 1.13$	0.09	13.20	$0.355^{b} \pm 0.004$
3	$63.58^{a} \pm 0.12$	$36.42^{d} \pm 0.13$	$17.89^{d} \pm 0.88$	$2.23^{a} \pm 0.09$	$12.34^{a} \pm 0.21$	$18.53^{d} \pm 0.98$	$66.90^{a} \pm 0.97$	0.19	27.37	$0.371^{ab} \pm 0.008$

*Mean values ± standard deviation (mean values followed by at least one different letter on the same column differ significantly by Tukey's test, $p < 0.05$); **Values based on Mesquita et al. (2016) study; ***g lactic acid/100 g.

presented as a resistant starch source, according to the current legislation which recommends 3 g of fiber/100 g of ice cream (Brasil, 2012). Furthermore, it is assumed that the preparation method for UBB has caused gelatinization and retrogradation of the starch present in unripe bananas, processes that can provide an increase in the yield of resistant starch (Patterson et al., 2020).

The titratable acidity was significantly higher in the formulations added with UBB (Table 2). Although not commonly required in current ice cream legislations, it is known that the determination of titratable acidity is considered an important quality parameter as it can influence characteristics such as flavor, color, and stability (Sadler & Murphy, 2010; Shipman et al., 2021). Although acidity showed significant difference among formulations, the numerical differences should be greater for sensory perception. Sour taste intensity can not be entirely explained by only one variable, such as titratable acidity (Ramos da Conceicao Neta et al., 2007; Turner & Liman, 2022).

The melting is an important physical parameter presented by ice creams. In this sense, the graphic behavior of the formulations added with UBB revealed a significant lower meltdown rates in the formulations with lower concentrations of UBB (Figure 1).

Owing to the ice cream is a complex colloidal system (Syed et al., 2018), it is not surprising that many factors can influence the melting pattern and, consequently, make interpretation and comparison of results difficult. The fat content, the fat globules, and agglomerates size, as well as their crystallization, the air incorporation, the stabilizers, the ice crystals size and the total solids content, among others, can influence the meltdown rate (Goff and Hartel, 2013). It is also worth noting that the higher fat content tends to promote greater incorporation of air and, consequently, a higher melting point, contributing to a more stable product (Carvalho et al. 2022). Thus, the lower the air incorporation rate, the higher is the meltdown rate. In spite of there is no reference value for the melting rate, there is a consensus that the ice cream should melts slowly and, at the end of the process, presents itself as a liquid, homogeneous and uniform mass (Souza et al., 2010).

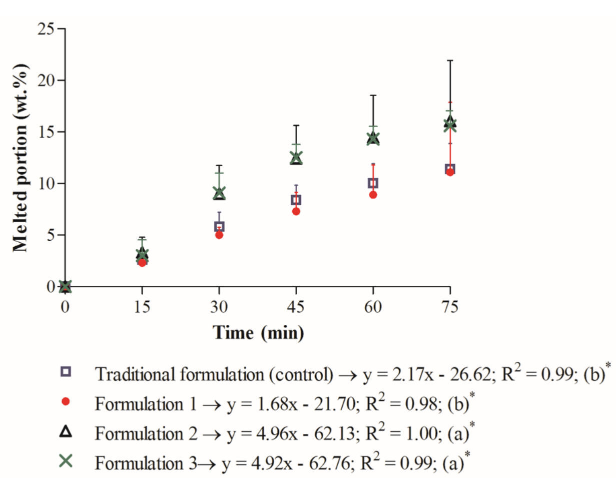

Figure 1. Meltdown profile. The equations were generated after exponential transformation to linearize the data. The slope represents the melting rate (g.min^{-1}). The experiment was carried out at least three times. *Different letters indicate significant difference in melting rate by Tukey's test ($p < 0.05$).

Considering that all formulations in the present study were produced from cow's milk, with standardization of the homogenization time, absence of the aging step and use of a domestic freezer for ice cream storage, similar fat globule sizes and low air incorporation are expected. In addition, homemade and artisanal ice cream generally have low air incorporation rates when compared to industrial ice cream (Goff & Hartel, 2013). Air incorporation rate has an inverse relationship with meltdown rate. It can be explained by the impact of air bubbles in the ability of heat penetration (thermal diffusivity), preventing ice cream melting (Sofjan & Hartel, 2004). For this reason, in these homemade ice creams, with low air incorporation, a higher melting rate was expected.

The total carbohydrate content, mainly soluble sugars, which contributes to the freezing point reduction (Li et al., 1997; Kurultay et al., 2010), is pointed out as the main cause of the faster meltdown rate (Frøst et al., 2005; Syed et al., 2018). This could explain the graphic behavior observed for formulations 2 and 3 (Table 2; Figure 1).

The effect of adding starch or resistant starch as a fat substitute in ice cream formulations has been reported in the literature (El-Nagar et al., 2002; Surapat & Rugthavon, 2003; Aykan et al., 2008; Akalın et al., 2008; Boff et al., 2013; Karaman et al., 2014; Aragão et al., 2018; Akbari et al., 2019). Starch acts as a stabilizing/thickening agent, increasing viscosity from moisture retention and gel formation. Consequently, it modifies the texture of ice cream (Akbari et al., 2019). The change in viscosity is not specific to starch, has also been observed in the production of ice cream with the addition of other prebiotics. The increase in viscosity, without impairing the acceptance, especially the texture attribute, was reported by Acu et al. (2021) when they added tagatose, litesse ultra and polydextrose to the tested symbiotic ice cream formulations. Nevertheless, the knowledge of the contribution of starch and other fat substitutes in important technological attributes for ice cream quality the meltdown rate is still controversial and incipient and requires careful analysis, since, as noted above, there are several interfering factors. Akbari et al. (2019) affirm that low-molecular-weight fat substitutes including fructooligosaccharides and inulin contribute to reducing the freezing point of ice cream, which makes the meltdown rate faster in low-fat ice cream. It is possible to observe in the literature studies that demonstrate reduction (El-Nagar et al., 2002; Karaman et al., 2014; Aragão et al., 2018; Zagorska et al. 2022; Santos et al. 2022), increase (Akalın et al., 2008) and little expressive variation (Surapat & Rugthavon, 2003; Aykan et al., 2008; Boff et al., 2013) in this physical behavior in formulations with addition of fat substitutes.

Probably the higher concentration of fat was a decisive factor in explaining the lower meltdown rates (Guinard et al., 1997; Stampanoni Koeferli et al. 1996; Carvalho et al., 2022; Frøst et al., 2005) observed in the traditional formulation and in formulation 1 (Table 2; Figure 1). On account of fat acts as a physical barrier to the growth of ice crystals (Donhowe et al, 1991) as well as decreases heat transfer (Goff & Hartel, 2013).

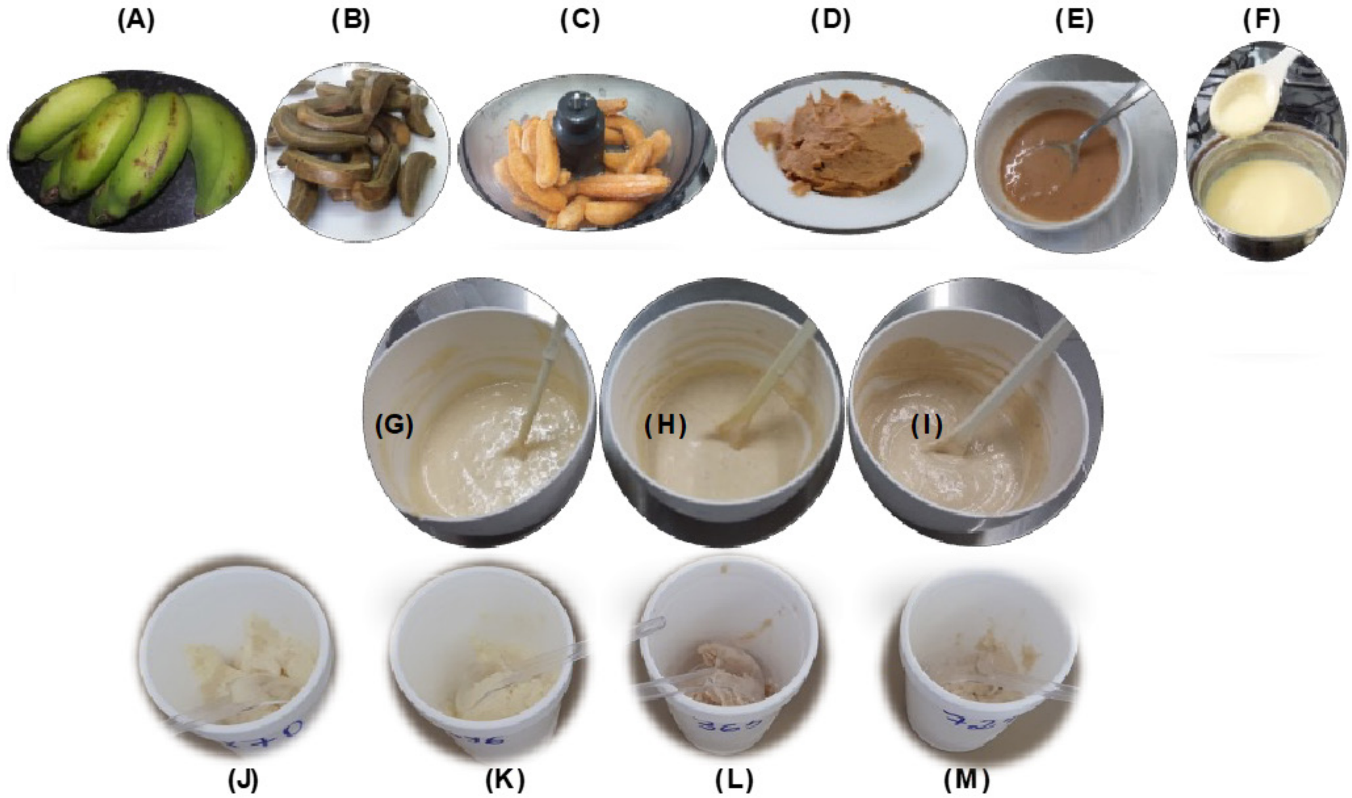

Figure 2. Photos of some steps of the ice cream preparation. (A) unripe banana; (B) unpeeled unripe banana after cooking; (C) peeled cooked unripe banana; (D) cooked unripe banana after mashing (unripe banana biomass-UBB); (E) reconstituted UBB; (F) "egg cream"; (G, H, I) and (K, L, M) Formulations 1, 2 and 3, respectively, before and after freezing; (J) Traditional formulation after freezing (control).

3.2 Microbiological quality and sensory characteristics of ice cream formulations

The formulations presented satisfactory microbiological quality to carry out the sensory analysis according to Brasil (2022b). *Salmonella* was absent and safe levels of coagulase-positive *Staphylococcus* and *Enterobacteriaceae* were found.

The UBB acquired firm and pasty consistency, in addition to an orange color after peeling and a light brown color after its processing and reconstitution. These characteristics contributed to the color pattern acquired by each formulation with increasing concentrations of UBB (Figure 2).

The preference ranking test performed in a descending way predicts that the lowest value of the sum of orders (total ordering) is an indicative of greater preference of the product by the evaluators (Table 3). Thus, the traditional formulation was preferred among the panellists. In addition, we concluded, based on the comparison between the difference modules with the critical value, that all formulations added with UBB differed from the traditional formulation. The formulation 1, indicated as the second most preferred by the panellists, differed from the others. Hence, the risk of rejection of ice cream rose with the increasing content of UBB.

Although non-fat solids, when in high concentrations, produce gritty, cooked and salty taste; and the total solids when in high concentrations can leave the ice cream with a heavy and pasty body (Goff & Hartel, 2013), it seems that the concentrations of these two components did not negatively influence the preference of panellists for the traditional formulation (Tables 2 and 3).

As a sample that is preferred will not always be accepted by a certain audience, it was decided to evaluate the acceptance of the two most preferred formulations. There was no difference

Table 3. Rank sum and difference module of the ice cream formulations on the preference ranking test.

Formulations	Rank sum
Traditional (control)	131
1	169
2	221
3	249
Difference versus	Difference module
Traditional - 1	38*
Traditional - 2	90*
Traditional - 3	118*
1 - 2	52*
1 - 3	80*
2 - 3	29

*Significant difference between samples ($p < 0.05$) considering 31 as the critical value of differences between rank sums for 4 samples and 77 panellists (Christensen et al., 2006).

between the mean values of the scores attributed by the evaluators to the traditional formulation and to formulation 1 in both acceptance and consumption intention test (Table 4).

The average score obtained in the acceptance test for the global impression, appearance, creamy texture, color, sweet taste, and vanilla flavor attributes was among 9 and 7-levels of the hedonic scale (Table 4) and covered at least 82% of the responses. In other words, it ranged from "Like extremely" to "Like moderately", respectively, for both the traditional formulation and formulation 1. Consequently, the evaluated formulations presented a positive result, since, according to Castro et al. (2007), to be considered acceptable in sensory terms products must present an acceptability index greater than 70%.

The creamy texture was the attribute with the lowest mean scores (Table 4). The frequency of the responses in the acceptance ranges among 9 and 7-levels of the hedonic scale was 82% for the traditional formulation and 86% for the formulation 1, when compared to the other attributes. Therefore, it is assumed that one of the reasons that could explain the rejection of ice cream formulations with higher UBB contents in the preference ranking test was the change in texture. Other studies have also demonstrated good acceptance of ice cream with fixed amount of fat and made from unripe banana pulp in the form of biomass (8,7% and 9,8%) (Wrobel & Teixeira, 2017) or flour (1% and 2%) (Yangilar, 2015), with scores in the acceptance test above 7 for similar attributes.

Despite, Prashanth et al. (2018) tested formulations with higher concentrations of unripe banana flour (2%, 4% and 6%) and obtained hedonic scores in acceptance test between 6 and 7, lower values when compared to our results.

Texture is one of the most important quality parameters of ice cream. In fact, it is a very complex sensory attribute as it is influenced by numerous factors. Adequate amounts of air, fat, stabilizers, emulsifiers, total solids and non-fat solids help to give body, can provide resistance to melting and result in good creaminess of the product (Souza et al., 2010). Therefore, many decisive factors for an adequate meltdown rate can be considered fundamental for a good ice cream texture. This fact partly explains why the traditional formulation was most preferred (Tables 3 and 4).

Admitting that the dairy fat plays an important role in the texture, creaminess, richness of flavor and body of ice cream, issues inherent to panellists must also be taken into account (Syed et al., 2018) since genetic predisposition, metabolic needs, and behavioral and emotional factors influence human preference for high-fat foods (Drewnowski & Almiron-Roig, 2010).

In the consumption intention test, the average scores assigned also ranged from 9 to 7-levels of the hedonic scale, from "I would eat this whenever I had the opportunity" to "I would eat this often" (Table 4). Scores among 9 and 7 were 83% and 80% of the responses of panellists for the traditional formulation and formulation 1, respectively. Therefore, the consumption intention of both formulations was positive, since there was a high frequency of panellists' responses close to score 9 of the hedonic scale.

The present study had limitations. When this study was planned, there was a lack of studies in the literature that evaluated different concentrations of UBB as a fat substitute in ice cream formulations. Therefore, the different UBB concentrations were empirically tested. Moreover, complementary analyzes such as fatty acid profile, fiber, resistant starch, and further the instrumental analysis of color and texture were not performed due to the following reasons. Firstly, according to Pivetta et al. (2020) the addition of UBB in concentrations similar to the present study, in cream cheese formulations, did not significantly modify the fatty acid profile. Secondly, we included the estimate of fiber and resistant starch content based on the study by Mesquita et al. (2016). Finally, the attributes "creamy texture", "appearance" and "color" have already been covered in the acceptance test.

On the other hand, this study presents strengths. This is the first work that proposed the development and characterization of homemade ice cream formulations added with the prebiotic ingredient UBB in partial replacement of fat. We observed that one of the added UBB formulations preserved important sensory and technological characteristics. Since the consumption intention of this same formulation was similar to the traditional one and showed good acceptability, we hypothesized that UBB can be used in the production of ice cream.

In a review study, Pimentel et al. (2022) point out two relevant aspects that could be evaluated in future research. Primarily, it is related to the positive effect of lower fat content in ice cream on

Table 4. Hedonic scores measured by Acceptance and Consumption intention tests and Acceptability index (%)

Test	Formulations	Mean ± Standard deviation	Sensory atributes (Mean ± Standard deviation)					
			Overall impression	Appearance	Creamy texture	Color	Sweet taste	Vanilla flavor
Acceptance test (Mean ± SD*)	Traditional	-	7.94 ± 1.40^{a}	7.83 ± 1.42^{a}	7.41 ± 1.77^{a}	7.98 ± 1.38^{a}	7.91 ± 1.62^{a}	8.13 ± 1.45^{a}
	Formulation 1	-	7.98 ± 1.31^{a}	7.90 ± 1.39^{a}	7.54 ± 1.69^{a}	7.87 ± 1.45^{a}	8.26 ± 1.37^{a}	8.06 ± 1.51^{a}
Consumption intention (Mean ± SD*)	Traditional	8.03 ± 1.15^{a}	-	-	-	-	-	-
	Formulation 1	7.92 ± 1.26^{a}	-	-	-	-	-	-
Acceptability index (%)	Traditional	-	88.22	87.00	82.33	88.67	87.89	90.33
	Formulation 1	-	88.67	87.78	83.78	87.44	91.78	89.56

*Mean values followed by at least one different letter on the same column differ significantly by Students t-test ($p < 0.05$).Acceptance test: n = 93 panellists; Consumption intention test: n = 93 panellists.

parameters that assess intestinal health (higher concentration of short-chain fatty acids and lower concentration of ammonia). Secondarily, it is associated with the use of prebiotics, such as UBB, in formulations added with probiotics. It has been shown that the combination of these two ingredients not only contributes to the production of short-chain fatty acids and reduction of fecal pH, however, also to the reduction of pathogenic bacteria counts, contributing to the modulation of the gastrointestinal microbiota. According to these authors, these effects, already observed in *in vitro* studies, have also been observed in *in vivo* experimental studies and in clinical trials.

4 Conclusion

The partial replacement of heavy cream with UBB was an effective way to reduce the fat content in homemade ice creams. Nonetheless, further studies are needed to demonstrate the ideal concentration of UBB that allows the maximum replacement of fat, increase in resistant starch content, and maintains desirable technological and sensory characteristics.

Acknowledgements

The authors would like to thank: FAPERJ (E-26/200.527/2017 and E-26/210.084/2022), PR5/UFRJ, FAPEMIG, CAPES and InfoGlish (https://www.instagram.com/infoglish/).

References

Acu, M., Kinik, O., & Yerlikaya, O. (2021). Probiotic viability, viscosity, hardness properties and sensorial quality of synbiotic ice creams produced from goat's milk. *Food Science and Technology (Campinas)*, 41(1), 167-173. http://dx.doi.org/10.1590/fst.39419.

Adomaitis, K., Boumphrey, S., Cesniene, I., Evans, M., Hodgson, A., Marceux, P., Mohiuddin, O., & Saltenyte, U. (2017). *Global economies and consumers in 2017*. Euromonitor International. Retrieved from http://go.euromonitor.com/rs/805-KOK-719/images/WP_Global_Economies_and_Consumers_in_2017.pdf

Akalın, A. S., Karagözlü, C., & Ünal, G. (2008). Rheological properties of reduced-fat and low-fat ice cream containing whey protein isolate and inulin. *European Food Research and Technology*, 227(3), 889-895. http://dx.doi.org/10.1007/s00217-007-0800-z.

Akbari, M., Eskandari, M. H., & Davoudi, Z. (2019). Application and functions of fat replacers in low-fat ice cream: a review. *Trends in Food Science & Technology*, 86, 34-40. http://dx.doi.org/10.1016/j.tifs.2019.02.036.

Amini Khoozani, A., Birch, J., & Bekhit, A. E. A. (2019). Production, application and health effects of banana pulp and peel flour in the food industry. *Journal of Food Science and Technology*, 56(2), 548-559. http://dx.doi.org/10.1007/s13197-018-03562-z. PMid:30906012.

Aragão, D. M., Araújo, Y. F. V., Carvalho, E. A. S., Gusmão, R. P., & Gusmão, T. A. S. (2018). Ice cream passion fruit flavored elaborated with green banana biomass and sucralose. *Revista Verde*, 13(4), 483-448. http://dx.doi.org/10.18378/rvads.v13i4.5353.

Arslaner, A., & Salik, M. A. (2020). Functional ice cream technology. *Akademik Gıda*, 18(2), 180-189. http://dx.doi.org/10.24323/akademik-gida.758835.

Aykan, V., Sezgin, E., & Guzel-Seydim, Z. B. (2008). Use of fat replacers in the production of reduced-calorie vanilla ice cream. *European Journal of Lipid Science and Technology*, 110(6), 516-520. http://dx.doi.org/10.1002/ejlt.200700277.

Boff, C. C., Crizel, T. M., Araujo, R. R., Rios, A. O., & Flôres, S. H. (2013). Desenvolvimento de sorvete de chocolate utilizando fibra de casca de laranja como substituto de gordura. *Ciência Rural*, 43(10), 1892-1897. http://dx.doi.org/10.1590/S0103-84782013001000026.

Brasil. Ministério da Agricultura, Pecuária e Abastecimento. (2022a). Aprova os requisitos de instalações, equipamentos e os procedimentos para o funcionamento de granjas avícolas e de unidades de beneficiamento de ovos e derivados a registradas no Departamento de Inspeção de Produtos de Origem Animal (Portaria SDA nº 612, de 6 de julho de 2022). *Diário Oficial da República Federativa do Brasil*. Retrieved from https://in.gov.br/en/web/dou/-/portaria-sda-n-612-de-6-de-julho-de-2022-414067462

Brasil. Ministério da Agricultura, Pecuária e do Abastecimento. Secretaria de Defesa Agropecuária. (2006). Oficializa Métodos Analíticos Oficiais Físico-Químicos, para Controle de Leite e Produtos Lácteos (Instrução Normativa nº 68, de 12 de dezembro de 2006). *Diário Oficial da República Federativa do Brasil*.

Brasil. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. (2012). Dispõe sobre o Regulamento Técnico sobre Informação Nutricional Complementar (Resolução RDC nº 54, de 12 de novembro de 2012). *Diário Oficial da República Federativa do Brasil*. Retrieved from https://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2012/rdc0054_12_11_2012.html

Brasil. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. (2022b). Estabelece os padrões microbiológicos de alimentos (Instrução Normativa nº 161, de 01 de julho de 2022). *Diário Oficial da República Federativa do Brasil*. Retrieved from http://antigo.anvisa.gov.br/documents/10181/2718376/IN_161_2022_.pdf/b08d70cb-add6-47e3-a5d3-fa317c2d54b2

Carvalho, C. C., Bodini, R. B., Sobral, P. J. A., & Oliveira, A. L. (2022). Ice creams made from cow's and goat's milks with different fat concentrations: physical-chemical and sensory properties. *Food Science and Technology (Campinas)*, 42, e79721. http://dx.doi.org/10.1590/fst.79721.

Castro, L. I. A., Vila Real, C. M., Pires, I. S. C., Pires, C. V., Pinto, N. A. V. D., Miranda, L. S., Rosa, B. C., & Dias, P. A. (2007). Quinoa (Chenopodium quinoa Willd): digestibilidade in vitro, desenvolvimento e análise sensorial de preparações destinadas a pacientes celíacos. *Alimimentos e Nutrição*, 18(4), 413-419. Retrieved from: https://www.researchgate.net/publication/49599772_QUINOA_CHENOPODIUM_QUINOA_WILLD_DIGESTIBILIDADE_IN_VITRO_DESENVOLVIMENTO_E_ANALISE_SENSORIAL_DE_PREPARACOES_DESTINADAS_A_PACIENTES_CELIACOS

Christensen, Z. T., Ogden, L. V., Dunn, M. L., & Eggett, D. L. (2006). Multiple comparison procedures for analysis of ranked data. *Journal of Food Science*, 71(2), S132-S143. http://dx.doi.org/10.1111/j.1365-2621.2006.tb08916.x.

Cirne, C. T., Tunick, M. H., Trout, R. E. (2019). The chemical and attitudinal differences between commercial and artisanal products. *npj Science of Food - Nature*, 19(3), 1-4. https://doi.org/10.1038/s41538-019-0053-9.

Donhowe, D. P., Hartel, R. W., & Bradley, R. L., Jr. (1991). Determination of ice crystal size distributions in frozen desserts. *Journal of Dairy Science*, 74(10), 3334-3344. http://dx.doi.org/10.3168/jds.S0022-0302(91)78521-4.

Downes, F. P., & Ito, K. (Eds.) (2001). *Standard methods for the microbiological examination of foods* (4th ed). Washington: American Public Health Association.

Drewnowski, A., & Almiron-Roig, E. (2010). Human perceptions and preferences for fat-rich foods. In J. P. Montmayeur & J. le Coutre (Eds.), *Fat detection: taste, texture, and post ingestive effects* (chap. 10). Boca Raton: CRC Press/Taylor & Francis. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK53528/

Dutcosky, S. D. (2013). *Análise sensorial de alimentos* (4. ed.). Curitiba: Champagnat.

El-Nagar, G., Clowes, G., Tudorică, C. M., Kuri, V., & Brennan, C. S. (2002). Rheological quality and stability of yog-ice cream with added inulin. *International Journal of Dairy Technology*, 55(2), 89-93. http://dx.doi.org/10.1046/j.1471-0307.2002.00042.x.

Falcomer, A. L., Riquette, R. F. R., de Lima, B. R., Ginani, V. C., & Zandonadi, R. P. (2019). Health benefits of green banana consumption: a systematic review. *Nutrients*, 11, 1222. http://dx.doi.org/10.3390/nu11061222. PMid:31146437.

Fida, R., Pramafisi, G., & Cahyana, Y. (2020). Application of banana starch and banana flour in various food product: a review. *IOP Conference Series. Earth and Environmental Science*, 443, 012057. http://dx.doi.org/10.1088/1755-1315/443/1/012057.

Fiol, C., Prado, D., Romero, C., Laburu, N., Mora, M., & Iñaki Alava, J. (2017). Introduction of a new family of ice creams. *International Journal of Gastronomy and Food Science*, 7, 5-10. http://dx.doi.org/10.1016/j.ijgfs.2016.12.001.

Food and Agriculture Organization of the United Nations – FAO. (2020). *Banana statistical compendium 2019*. Rome: FAO. Retrieved from http://www.fao.org/publications/card/en/c/CB0466EN

Frøst, M. B., Heymann, H., Bredie, W. L. P., Dijksterhuis, G. B., & Martens, M. (2005). Sensory measurement of dynamic flavor intensity in ice cream with different fat levels and flavourings. *Food Quality and Preference*, 16(4), 305-314. http://dx.doi.org/10.1016/j.foodqual.2004.05.009.

Goff, H. D., & Hartel, R. W. (2013). *Ice cream* (7th ed.). New York: Springer. https://doi.org/10.1007/978-1-4614-6096-1.

Guinard, J.-X., Zoumas-Morse, C., Mori, L., Uatoni, B., Panyam, D., & Kilara, A. (1997). Sugar and fat effects on sensory properties of ice cream. *Journal of Food Science*, 62(5), 1087-1094. http://dx.doi.org/10.1111/j.1365-2621.1997.tb15044.x.

Instituto Adolfo Lutz – IAL. (2008). *Métodos físico-químicos para análise de alimentos* (4. ed.). São Paulo: IAL.

Karaman, S., Toker, Ö. S., Yüksel, F., Çam, M., Kayacier, A., & Dogan, M. (2014). Physicochemical, bioactive, and sensory properties of persimmon-based ice cream: technique for order preference by similarity to ideal solution to determine optimum concentration. *Journal of Dairy Science*, 97(1), 97-110. http://dx.doi.org/10.3168/jds.2013-7111. PMid:24268400.

Kurultay, Ş., Öksüz, Ö., & Gökçebağ, Ö. (2010). The influence of different total solid, stabilizer and overrun levels in industrial ice cream production using coconut oil. *Journal of Food Processing and Preservation*, 34, 346-354. http://dx.doi.org/10.1111/j.1745-4549.2009.00418.x.

Li, Z., Marshall, R., Heymann, H., & Fernando, L. (1997). Effect of milk fat content on flavor perception of vanilla ice cream. *Journal of Dairy Science*, 80(12), 3313-3341. http://dx.doi.org/10.3168/jds.S0022-0302(97)76284-2. PMid:9436093.

López-Martínez, M. I., Moreno-Fernández, S., & Miguel, M. (2021). Development of functional ice cream with egg white hydrolysates. *International Journal of Gastronomy and Food Science*, 25, 100334. http://dx.doi.org/10.1016/j.ijgfs.2021.100334.

Mesquita, C. B., Leonel, M., Franco, C. M. L., Leonel, S., Garcia, E. L. G., & Santos, T. P. R. (2016). Characterization of banana starches obtained from cultivars grown in Brazil. *International Journal of Biological Macromolecules*, 89, 632-639. http://dx.doi.org/10.1016/j.ijbiomac.2016.05.040. PMid:27180297.

Nielsen. (2021). *An inside look into the 2021 Global Consumer Health and Wellness revolution*. Retrieved from https://nielseniq.com/wp-content/uploads/sites/4/2022/05/NIQ_Global_Health_and_Wellness_Report_2021_1-1.pdf

Patterson, M. A., Maiya, M., & Stewart, M. L. (2020). Resistant starch content in foods commonly consumed in the United States: A narrative review. *Journal of the Academy of Nutrition and Dietetics*, 120(2), 230-244. http://dx.doi.org/10.1016/j.jand.2019.10.019. PMid:32040399.

Petrescu, D. C., Vermeir, I., & Petrescu-Mag, R. M. (2019). Consumer understanding of food quality, healthiness, and environmental impact: a cross-national perspective. *International Journal of Environmental Research and Public Health*, 17(1), 169. http://dx.doi.org/10.3390/ijerph17010169. PMid:31881711.

Pimentel, T. C., de Oliveira, L. I. G., de Souza, R. C., & Magnani, M. (2022). Probiotic ice cream: A literature overview of the technological and sensory aspects and health properties. *International Journal of Dairy Technology*, 75(1), 59-76. http://dx.doi.org/10.1111/1471-0307.12821.

Pivetta, F. P., Silva, M. N., Tagliapietra, B. L., & Richards, N. S. S. (2020). Addition of green banana biomass as partial substitute for fat and encapsulated *Lactobacillus acidophilus* in requeijão cremoso processed cheese. *Food Science and Technology (Campinas)*, 40(2), 451-457. http://dx.doi.org/10.1590/fst.03919.

Plasek, B., Lakner, Z., Temesi, Á. (2020). Factors that influence the perceived healthiness of food-Review. *Nutrients*, 12(6), 1881. https://doi.org/10.3390/nu12061881.

Prashanth, P., Singh, J. K., Maloo, S., & Bhaskar, V. (2018). Enrichment of probiotic ice-cream with prebiotic green banana flour (Resistant starch). *International Journal of Food Sciences and Nutrition*, 3(6), 190-193. Retrieved from http://www.foodsciencejournal.com/archives/2018/vol3/issue6/3-6-48

Ramos da Conceicao Neta, E. R., Johanningsmeier, S. D., & McFeeters, R. F. (2007). The chemistry and physiology of sour taste - A review. *Journal of Food Science*, 72(2), R33-R38. http://dx.doi.org/10.1111/j.1750-3841.2007.00282.x. PMid:17995849.

Reis, R. C., & Minim, V. P. R. (2013). Testes de aceitação. In V. P. R. Minin (Ed.), *Análise sensorial: estudos com consumidores* (pp. 66-82). Viçosa: Editora UFV.

Sadler, G. D., & Murphy, P. A. (2010). pH and titratable acidity. In S. S. Nielsen (Ed.), *Food analysis* (pp. 219-238). Boston: Springer. https://doi.org/10.1007/978-1-4419-1478-1_13.

Santos, P. P. A., Ferrari, G. S., Rosa, M. S., Almeida, K., Araújo, L. A., Pereira, M. H. C., Wanderley, M. E. F., & Morato, P. M. (2022). Desenvolvimento e caracterização de sorvete funcional de alto teor proteico com ora-pro-nóbis (*Pereskia aculeata* Miller) e inulina. *Brazilian Journal of Food Technology*, 25, e2020129. http://dx.doi.org/10.1590/1981-6723.12920.

Shipman, E. N., Yu, J., Zhou, J., Albornoz, K., Beckles, D. M. (2021). Can gene editing reduce postharvest waste and loss of fruit, vegetables, and ornamentals? *Horticulture Research – Nature*, 8(1), 1-21. http://dx.doi.org/10.1038/s41438-020-00428-4.

Silva, D. J., & Queiroz, A. C. (2002). *Análise de alimentos: métodos químicos e biológicos* (3. ed). Viçosa: Editora UFV.

Smet, K., De Block, J., Van Der Meeren, P., Raes, K., Dewettinck, K., & Coudijzer, K. (2010). Influence of milk fatty acid composition and process parameters on the quality of ice cream. *Dairy Science & Technology*, 90(4), 431-447. http://dx.doi.org/10.1051/dst/2010006.

Sofjan, R. P., & Hartel, R. W. (2004). Effects of overrun on structural and physical characteristics of ice cream. *International Dairy Journal*, 14(3), 255-262. http://dx.doi.org/10.1016/j.idairyj.2003.08.005.

Souza, J. C. B., Costa, M. R., Rensis, C. M. V. B., & Sivieri, K. (2010). Sorvete: composição, processamento e viabilidade da adição de probiótico. *Alimentos e Nutrição*, 21(1), 155-165. Retrieved from https://www.researchgate.net/publication/49600215

Spence, C., Navarra, J., & Youssef, J. (2019). Using ice-cream as an effective vehicle for energy/nutrient delivery in the elderly. *International Journal of Gastronomy and Food Science*, 16, 100140. http://dx.doi.org/10.1016/j.ijgfs.2019.100140.

Stampanoni Koeferli, C. R., Piccinali, P., & Sigrist, S. (1996). The influence of fat, sugar and non-fat milk solids on selected taste, flavor and texture parameters of a vanilla ice-cream. *Food Quality and Preference*, 7(2), 69-79. http://dx.doi.org/10.1016/0950-3293(95)00038-0.

Steele, E. M., Rauber, F., Costa, C. S., Leite, M. A., Gabe, K. T., Louzada, M. L. C., Levy, R. B., & Monteiro, C. A. (2020). Dietary changes in the NutriNet Brasil cohort during the covid-19 pandemic. *Revista de Saude Publica*, 54, 91. http://dx.doi.org/10.11606/s1518-8787.2020054002950. PMid:32901755.

Surapat, S., & Rugthavon, P. (2003). Use of modified starch as fat replacer in reduced fat coconut milk ice cream. *Witthayasan Kasetsat Witthayasat*, 37, 484-492. Retrieved from https://www.thaiscience.info/journals/Article/TKJN/10898572.pdf

Syed, Q. A., Anwar, S., Shukat, R., & Zahoor, T. (2018). Effects of different ingredients on texture of ice cream. *Journal of Nutrition Health & Food Engeneering*, 8(6), 422-435. http://dx.doi.org/10.15406/jnhfe.2018.08.00305.

Turner, H. N., & Liman, E. R. (2022). The cellular and molecular basis of sour taste. *Annual Review of Physiology*, 84(1), 41-58. http://dx.doi.org/10.1146/annurev-physiol-060121-041637. PMid:34752707.

von Loesecke, H. W. (1950). *Bananas: chemistry, physiology, technology*. New York: Interscience Publishers, Inc.

Welti-Chanes, J., Serna-Saldívar, S., Campanella, O., & Tejada-Ortigoza, V. (Eds.) (2020). Science and technology of fibers in food systems. In G. V. Barbosa-Cánovas (Ed.), *Food engineering series*. Switzerland: Springer. http://dx.doi.org/10.1007/978-3-030-38654-2.

World Health Organization – WHO. (2020). *Healthy diet*. Retrieved from https://www.who.int/news-room/fact-sheets/detail/healthy-diet

Wrobel, A. M., & Teixeira, E. C. O. (2017). *Elaboração e avaliação sensorial de um sorvete de chocolate com adição de biomassa de banana verde (Musa spp)*. (Trabalho de Conclusão de Curso). Universidade Tecnológica Federal do Paraná, Ponta Grossa.

Yangilar, F. (2015). Effects of green banana flour on the physical, chemical and sensory properties of ice cream. *Food Technology and Biotechnology*, 53(3), 315-323. http://dx.doi.org/10.17113/ftb.53.03.15.3851. PMid:27904363.

Zagorska, J., Paeglite, I., & Galoburda, R. (2022). Application of lactobionic acid in ice cream production. *International Journal of Dairy Technology*, 75(3), 701-709. http://dx.doi.org/10.1111/1471-0307.12873.

Zeng, H., Chen, P., Chen, C., Huang, C., Lin, S., Zheng, B., & Zhang, Y. (2018). Structural properties and prebiotic activities of fractionated lotus seed resistant starches. *Food Chemistry*, 251, 33-40. http://dx.doi.org/10.1016/j.foodchem.2018.01.057. PMid:29426421.