

Food Science and Applied Biotechnology

e-ISSN: 2603-3380

Journal home page: www.ijfsab.com
<https://doi.org/10.30721/fsab2020.v3.i1>



Research Article

Effects of fructose and stevia on the rheological, technological and sensory characteristics of ice cream

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Abstract

This study investigated the potential use of fructose and stevia to improve the technological parameters of ice cream. Ice cream was made of 2 different mixtures. Low-fat ice cream mixtures (0.4% fat) were made with: sweet buttermilk, 5% fructose, 20% banana puree, and sweet buttermilk, 5% fructose, 20% pear puree. The ice cream with stevia was made with cream (13% fat), milk, skim milk powder and whey powder, cherry puree (16%) and 0.48% stevia solution (20% concentration). The ice cream with banana showed rapid melting rate and the highest acidity. On the contrary, the ice cream with pear showed lower melting rate, but caused to increase the hardness and resulted with less overall acceptability. The enrichment of the ice cream with stevia and cherry showed the same coherence of hardness and overall acceptability.

Keywords: ice cream, low-fat, fructose, stevia, sweet buttermilk, melting, hardness

Abbreviations:

BM – buttermilk

^oT – a measure of the acidity of milk

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Article history:

Received: 8 September 2019

Reviewed: 29 October 2019

Accepted: 18 November 2019

Available on-line: 19 March 2020

<https://doi.org/10.30721/fsab2020.v3.i1.92>

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Introduction

Ice cream is one of the most popular “luxury” products worldwide and the popularity of this product is growing fast. Studies have shown that a growing consciousness of health has led to a change in consumer demands and manufacture offerings in ice cream, including smaller portion size, lower levels of fat and a desire of functional use (Salem et al. 2005; Cruz et al. 2009, Kurt and Atalar 2018). Increasing demand for sweet treats is the major factor driving the ice cream sector. The growth of low fat and organic ice cream is changing the ice cream production landscape. Ice cream manufacturers are in turn seeking to maximize the nutritional benefits of the products they sell. New flavors and varieties are constantly cropping up to entice consumers. (Akbariy et al. 2019).

The effect of the addition of prebiotics ingredients on the quality parameters of ice cream has also been investigated. According to the authors, ice cream was generally found to improve the acid and bile tolerance of the probiotics compared to plain and stirred fruit yogurts. *In vitro* gastric survival of probiotics was improved in the presence of ice cream (Ranadheera et al. 2012). The ice cream with added *B. animalis* was evaluated in regard to the probiotic viability during processing, frozen storage and simulated gastrointestinal conditions. Results showed that the addition of *B. animalis* decreased the pH, but it had no effect on physicochemical properties, including overrun and melting behavior of ice cream and received good sensory scores and satisfactory probiotic viability (Lima da Silva et al. 2015).

Buttermilk is the aqueous phase released during the churning of cream in butter manufacture. The high content of phospholipids in buttermilk (BM) makes this dairy ingredient interesting for the use as a functional ingredient because of the emulsifying properties of phospholipids (Sodini et al. 2006). Some studies have demonstrated the influence of BM addition to higher volatile compounds of cheese and an improvement of the flavor in low-fat yoghurt (Hickey et al. 2018; Zhao et al. 2018).

Consumer demands for healthier products are leading to push for sugar reduction in dairy foods. Sugar plays an important role in ice cream, not only in flavor but also in texture, color and viscosity.

Natural and artificial sweeteners exist for the purpose of sugar reduction (McCain et al. 2018). However, little information exists about the influence of high-intensity sweeteners and fat replacers on the perception of sensory attributes of ice-cream (Cadena et al. 2012).

The aims of this study were: (1) to determine compositional and sensory properties of low-fat ice cream with fructose, (2) to evaluate chemical, textural and sensory qualities of ice cream with stevia during storage.

Materials and Methods

Ice cream samples. The buttermilk ice cream was formulated (Table 1) with sweet BM (BM was pasteurized at 95°C for 5min), skim milk powder and YO-FLEX yogurt thermophilic culture. The mixture was inoculated at (40-42) °C for 5 hours until the pH reached 4.6. Then mixture was blended with stabilizer and divided into three portions: the first mixture was left in the control without the additional ingredients, 20% banana puree and 5% fructose were added to the second mixture and 20% pear puree and 5% fructose to the third mixture. The cooled mixtures were stored at refrigeration temperature of 6°C for 40min and frozen into ice cream with overrun set at 45%. The products were packaged into 120ml cups and kept in a -18°C freezer.

The ice cream with stevia samples (Table 1) was manufactured as follows: milk and cream were heated to 50°C, then milk and whey powders were added. After the addition of the emulsifier and stabilizers, the ice cream mix was pasteurized at 85°C for 25s and then rapidly cooled to 10°C. The ice cream mixture was aged at 6°C for 40min. After the aging process the mixture was divided into three parts: a mixture with stevia, a mixture with cherries puree and a mixture with stevia and cherries puree.

Titrateable acidity. The acidity was determined with a standardized solution of 0.1N sodium hydroxide and taking 5g of each sample adding 80ml of distilled water with added phenolphthalein indicator (prepared at 1% in ethanol at 95%) and titrated until the first dye of light pink is permanent. Titrateable acidity, expressed as degrees of Therner (°T). All analyses were carried out at least in triplicate.

Sensory evaluation. Sensory evaluation was carried out in ice cream samples during 1 month of storage at -18°C . Sensory analysis was performed by a group of 30 panelists. The ice cream samples (10g) were coded with a 3-digit random number and organoleptically assessed by the panelists using a sensory rating scale of 1 to 5 for taste, flavor and texture. Scores were assigned to 3 attributes of aroma, to 6 attributes of body/texture, to 6 attributes of taste.

Evaluation of the melting rate. The melting rates of the ice cream samples were analyzed at room temperature ($24\pm 2^{\circ}\text{C}$). Fifty-gram samples were weighed and placed in suspended sieves at controlled ambient temperature. The volumes of ice cream were measured over 30min. The measurements were done in triplicate. Melting rate

was measured as the weight of drip versus time (Akalm et al. 2018).

Texture analysis. Analysis of hardness was conducted using a LLOYD TA1 Texture Analyzer (United Kingdom) at 23°C . The penetration depth at the geometrical center of the samples was 20mm, the trigger load was 5.6N force, and the test speed was 21mm/min.

Results and Discussion

Characterization of the BM ice cream

The titratable acidity results (Fig. 1) showed that fructose, banana and pear reduced ice cream acidity. The addition of the new ingredients to the BM ice cream caused a decrease in acidity due to the lower acidity of the fruits (Akalin et al. 2018).

Table 1. Ice cream formula.

| Low fat (BM) ice cream | Ingredients | Ice cream with stevia | Ingredients |
|------------------------|----------------------------------------------------------------------------------------|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Control ice cream | Sweet buttermilk yoghurt Skim milk powder, 15% | Ice cream with cherry | Milk 47.75g/100g Cream (38% fat) 26.15g/100g Skim milk powder 7.6g/100g Whey powder 2.5g/100g Cherry puree 16% |
| Ice cream with banana | Sweet buttermilk yoghurt Skim milk powder, 15% Banana puree, 20% Fructose, 5% | Ice cream with stevia | Milk 63.25g/100g Cream (38% fat) 26.15g/100g Skim milk powder 7.6g/100g Whey powder 2.5g/100g Stevia syrup 0.5% |
| Ice cream with pear | Sweet buttermilk yoghurt Skim milk powder, 15% Pear puree, 20% Fructose, 5% | Ice cream with stevia and cherry | Milk 47.25g/100g Cream (38% fat) 26.15g/100g Skim milk powder 7.6g/100g Whey powder 2.5g/100g Cherry puree 16% Stevia syrup 0.5% |

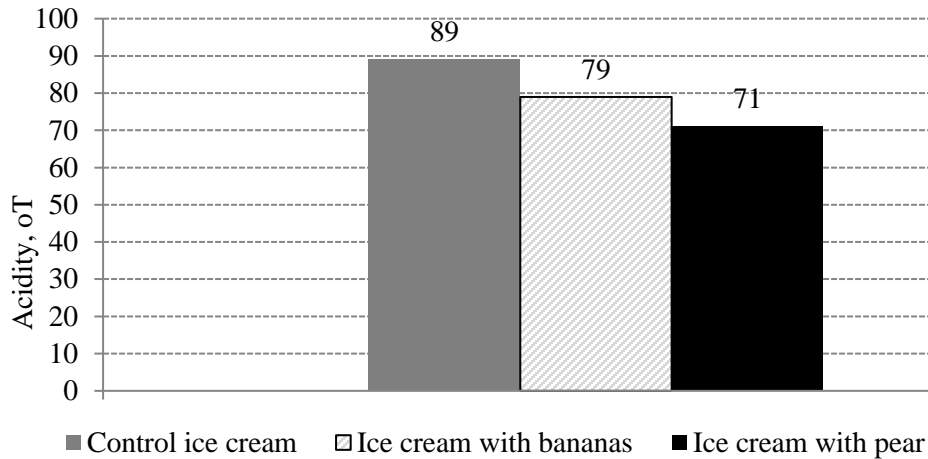


Figure 1. The effect of the flavour additives on BM ice cream acidity.

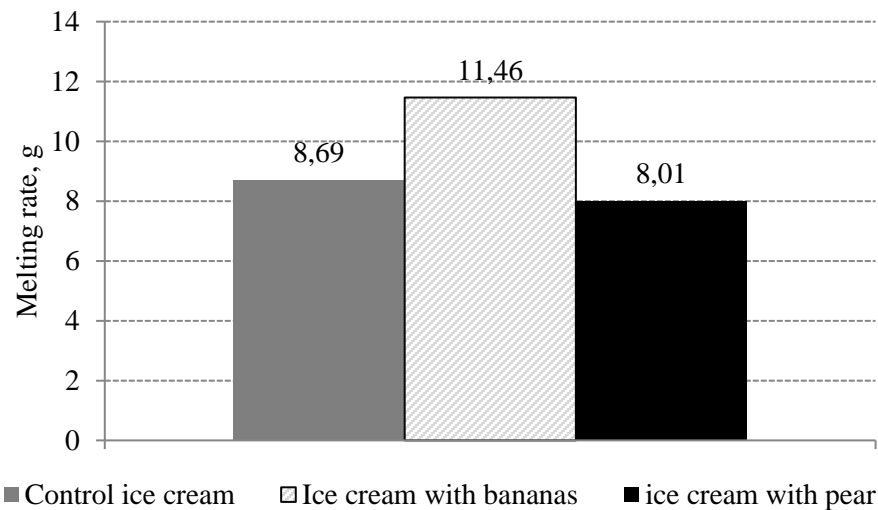


Figure 2. The effect of the flavour additives on BM ice cream melting rate.

Figure 2 shows that the highest melted weight was found in the BM ice cream with bananas (11.46g). In contrast, the control ice cream and the ice cream with pear showed the lowest melting rate (8.01g). [Balthazar et al. \(2015\)](#) also detected a decrease in the melting rate of the ice cream with galactooligosaccharide samples with higher acidity. The hardness values of the ice cream samples are shown in Fig. 3. The results indicated that the hardness increased for the control ice cream (60.4N)

in the same way as in the BM ice cream with pear (51.12N). In contrast, the lowest hardness values were detected in the BM ice cream with bananas (2.46N). This effect can be attributed to the non-gelling properties of bananas resulting in the increase of ice crystallization ([Karaman et al. 2014](#)). Similarly, [Akalin et al. \(2018\)](#) reported that the highest viscosity in the ice cream mix, did not lead to the ice cream sample with higher firmness.

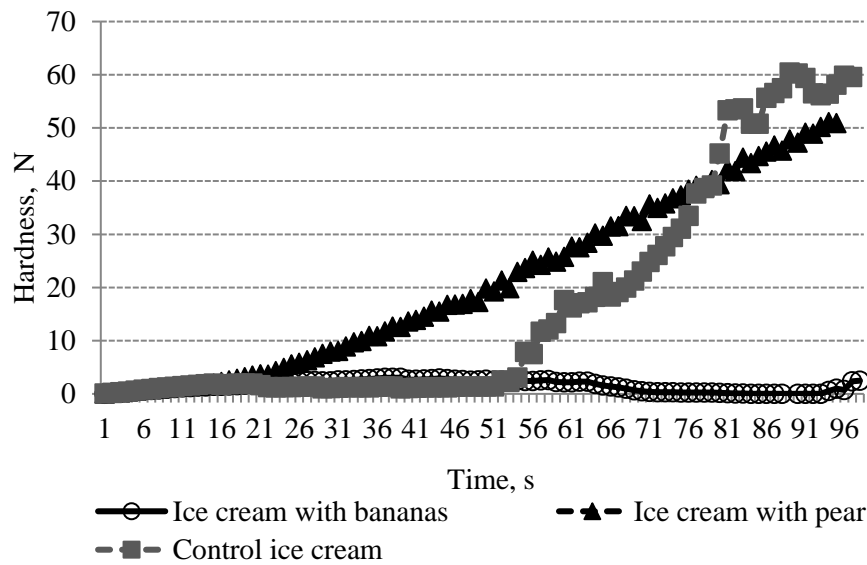


Figure 3. The effect of the flavour additives on BM ice cream hardness.

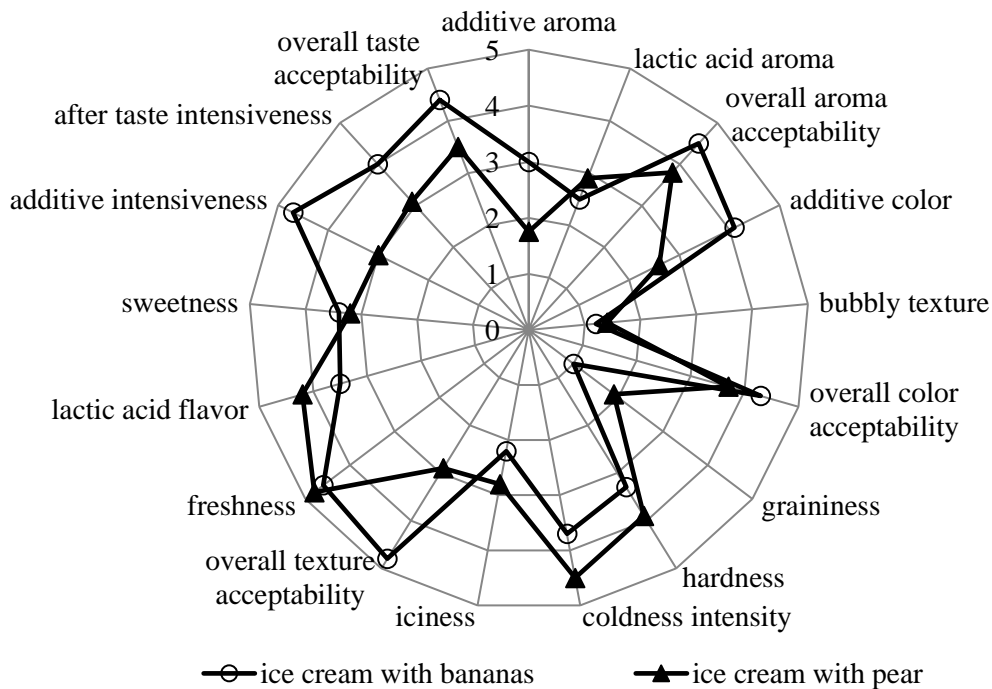


Figure 4. The sensory characteristics of BM ice cream.

The sensory evaluation (Fig.4) carried out by the panelists showed that the BM ice cream with bananas was characterized by the highest scores of overall texture, taste and aroma acceptability and additive intensiveness. Both BM ice creams with

banana and pear had lower scores of iciness and graininess. This probably was because these BM ice creams was made with fresh pasteurized banana puree and pear puree and gave the impression of fat feel and mouth coating. Similar results were found

for the Italian gelato of mango and banana (Thomson et al. 2009). Fat feel/mouth-coating-type attributes are associated with the dairy products, in particular milk and cream.

Characterization of the ice cream with stevia

As can be seen in the Figure 5, the acidity of ice cream with stevia samples (34^oT) was constant during the storage (21 days). The twice acidic of ice creams with cherry (75^oT) had been obtain due to acidity of cherry.

The results of hardness during storage are shown in Figure 6. The hardness increased of each sample of the ice cream due to increasing amount of ice crystal during storage. The hardness of the stevia-cherry based ice cream increased slowly during 21 day of storage (16.08N). Whereas the hardness of the ice cream with cherry reached 65.458N. The ice cream with cherry showed higher firmness than the stevia and stevia-cherry based ice cream. The replacement of sugar with stevia or cherry puree affected the hardness of the ice cream. The main reason of such

observation was increased concentration of water from cherries. When fat content is decreased and compensated with water, then ice crystals were larger, resulting a harder texture (Pintor et al. 2017). This may be due to the microstructure change: ice crystal size, fat stability. Several studies have reported that concentration of stevia affected amount of ice formation (Pon et al. 2015). Stevia ice cream is described as having more chewy texture. The sustainability of stevia ice cream in the mouth was also supported by the increment of gumminess. As a secondary texture profile, gumminess is defined as the product of hardness.

Sensory scores of the ice cream samples are illustrated in Figure 7. The addition of cherries developed the sensory properties of the ice cream and increased the cherry aroma, freshness and sweet flavor of the product compared with the ice cream with stevia. A significant difference was determined regarding creaminess and powder flavor of the ice cream. Stevia based ice cream associated with higher scores of texture and flavor attributes.

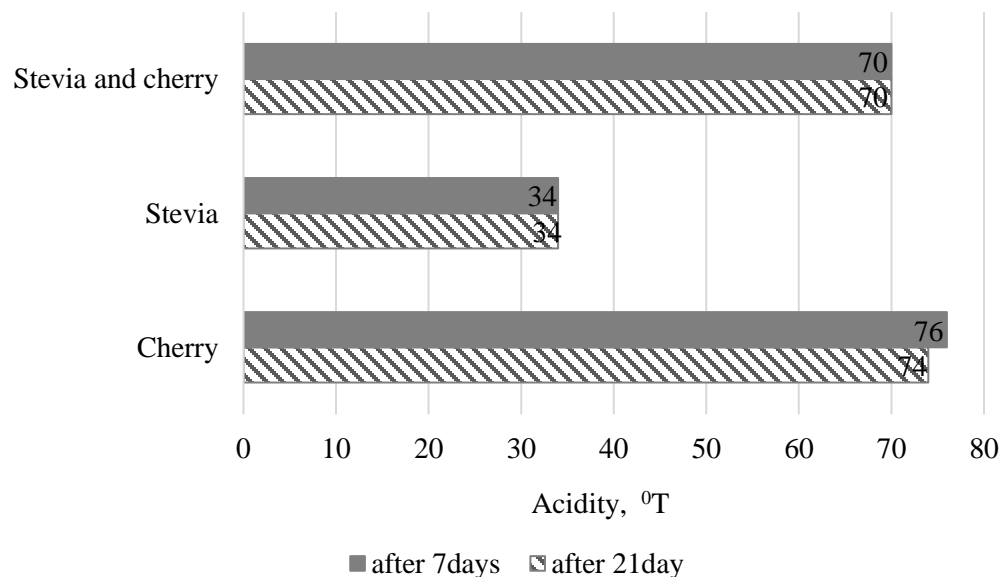


Figure 5. The evaluation of ice cream acidity during storage.

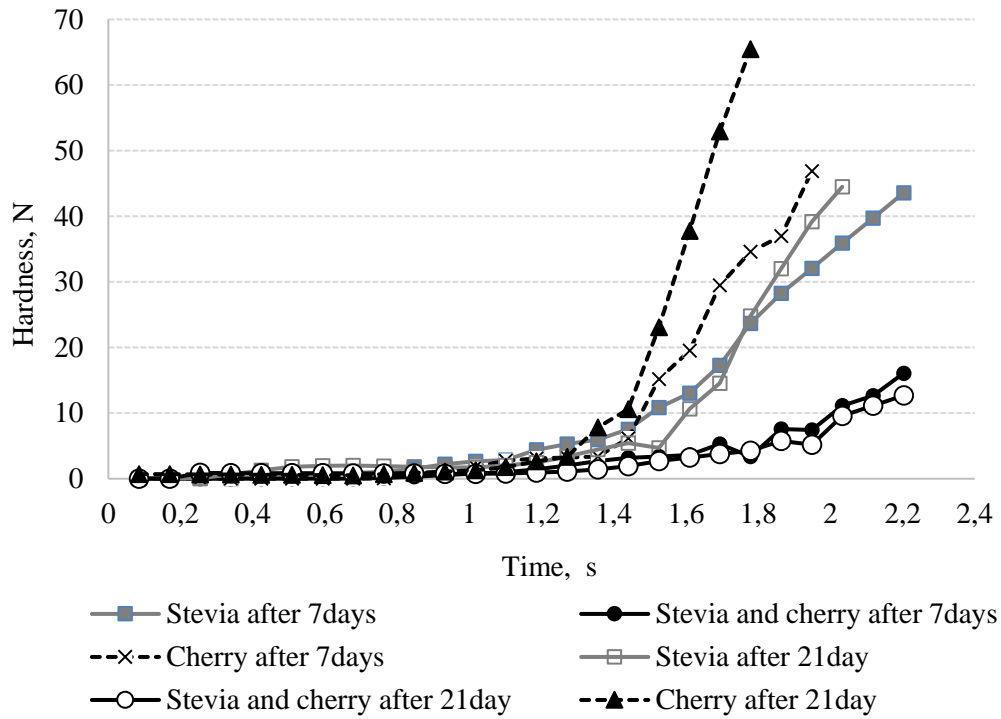


Figure 6. The evaluation of ice cream hardness during storage.

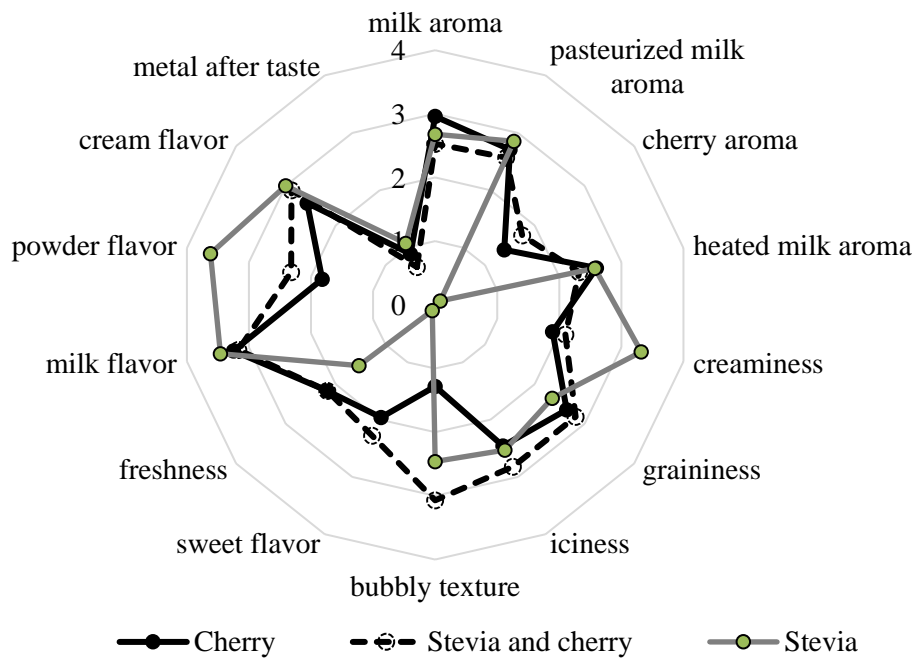


Figure 7. The sensory scores of ice cream with stevia.

Conclusions

The findings of this study showed that the BM ice cream with banana showed rapid melting rate, the highest acidity and the lowest hardness values. On the contrary the BM ice cream with pear showed lower melting rate, but caused to increase the hardness and resulted in less overall acceptability. In addition, the results suggested that the presence of stevia in the ice cream had a positive effect on the acidity and hardness. The increase in hardness of the ice cream with stevia contributed to a greater stability of the product. From the sensory point of

view, the addition of cherries to the stevia based ice cream was more acceptable for the consumers.

Acknowledgements

We express our gratitude to Kauno kolegija/University of Applied Science, for providing us with the labs to perform analysis of this study.

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