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Making ice cream with natural sweetener stevia: Formulation and characteristics

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ABSTRACT

In the modern era, ice cream is a widely consumed dessert in our society. The main aim of the study is replacement of sugar by natural Sweetener and create good quality of ice cream. Based on chemical, physical, and microbiological parameters, ice cream was examined. In our study, we used one formulated ice cream (FIC) and five distinct brand ice creams (A, B, C, D, and E). When sucrose was replaced with stevia, the resulting ice cream had reduced total solids, fat, ash, freezing point, and hardness (29.43 ± 1.56%; 8.42 ± 0.19%; 0.82 ± 0.07%; 2.29 ± 0.17 °C; 42.98 ± 3.27 N for FIC and 32.87 ± 1.07 to 35.09 ± 1.18%; 9.90 ± 0.14 to 10.28 ± 0.16%; 3.43 ± 0.13 to 3.67 ± 0.12%; 3.21 ± 0.18 to 3.35 ± 0.10 °C; 43.24 ± 3.57 to 46.21 ± 3.76 N for all brands) but greater protein, viscocity, and sensory test values (3.74 ± 0.23%; 93.21 ± 1.98 cP; 7.54 for FIC and 2.12 ± 0.08 to 2.40 ± 0.14%; 90.32 ± 1.97 to 92.26 ± 1.29 cP; 6.95 to 7.33 for all brands) when compared to brands that used sucrose as their sweetener. Among all the brands, FIC sensory acceptability was the highest. We came to the conclusion that substituting stevia for sucrose may be an option for diabetic patients as well as persons of all ages.

1. Introduction

Ice cream is currently the most popular frozen food consumed globally (Alizadeh et al., 2014). A combination of unfrozen components for example milk, fat, sugar, and flavors are used to make this semi-solid, cold food product. It now has more significance within the dairy business and relates to one of the most well-known dairy products (Akalın et al., 2008). The high calorific value of ice cream is mainly due to its high level of fat, protein, and carbohydrate. 100 g of decent, standard ice cream contains 200 kcal of calories. As a result of consumer demand for healthier and more valuable foods, new manufacturing techniques have been developed (Akin et al., 2007; Soukoulis et al., 2009; Soukoulis & Tzia, 2010). Developing lower-fat, lower-sugar products could boost sales, particularly for frozen sweets (Olson et al., 2003). Three of the most critical structural elements of ice cream are ice crystals, air cells, and fat corpuscles, all of which are dispersed in a coupled phase from a non-frozen solution (Marshall, 1996). Sweeteners influence texture, viscosity, and the freezing point making them one of the ingredients that have a more significant impact on consumer acceptance (Alizadeh et al., 2014). Ice cream's overall composition includes between 3 and 15% fat, and 9 and 28% sugar (Goff, 2018). Systolic blood pressure, hypertension, and other conditions are all exacerbated by sucrose. Additionally, it aggravates diabetes (Deshmukh et al., 2014).

The primary cause of death in most nations and a significant regional and worldwide public health issue is diabetes (Zimmet et al., 2014). According to the IDF (International Diabetes Federation), there were 465 million (9.3%) cases of diabetes globally in 2019, and by 2045, that figure might reach 700 million (10.9%) (Atlas, 2019). The prevalence of adult pre-diabetes was 374 million (7.5%) in 2019 and is projected to increase to 548 million (8.6%) by 2045, similar to pre-diabetes. On average, patients with type 2 diabetes mellitus (T2DM) have a 10 year decline in life expectancy and cardiovascular problems account for 80% of T2DM patient deaths (Guariguata et al., 2014). Diabetes prevalence is continuously growing in Bangladesh. In Bangladesh's International centre for Diarrhoeal Disease Research, 7.1 million people had diabetes in 2015; 3.7 million cases went undiagnosed, and the condition was responsible for about 129,000 fatalities (International Centre, 2019). According to research that has been published, Bangladesh has a prevalence of diabetes that ranges from 2.21%–35% (Akhtar et al., 2020).

Ice cream has been manufactured using a combination of sweeteners. The most popular sweetener in ice cream manufacture is sucrose because of rheological and financial concerns. It has a high glycemic index, which is correlated with the metabolic syndrome, type 2 diabetes, obesity, coronary heart disease, hypertension, and dental caries (Aliha et al., 2013; Alizadeh et al., 2014). Even though these substances produce little or no calories, some safety concerns have been highlighted, including

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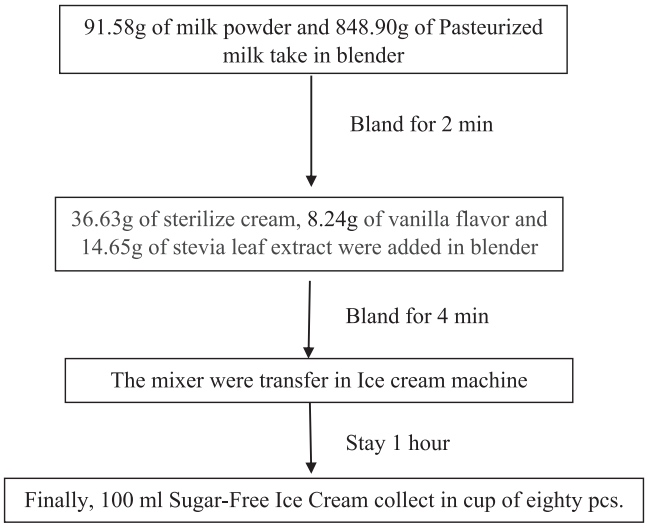


Fig. 1. Preparation of Sugar-Free Ice Cream.

their potential for cancer, teratogenicity, and interaction with certain metabolic or vascular illnesses. As a result, various efforts have been made to produce foods containing sugar while using natural sweeteners (Mahan & Escott-Stump, 2013).

In general, sweeteners can be categorized as either natural or synthetic. Depending on the dispersion matrix, natural sweetener *stevia rebaudiana* (*S. rebaudiana*) is 250 to 300 times sweeter than sucrose (Adari et al., 2016). Those with diabetes mellitus and other sedentary lifestyle-related diseases might use it as a healthy alternative to sugar because of its exceptionally low calorie content (one gram has no calories) (Curry & Roberts, 2008). The JECFA, WHO, and FDA acknowledge stevia as a safe supplement with rather high maximum limits (FAO/WHO, 2004; Reddy et al., 2005, 2010).

Since the 1950s, Bangladesh has had an ice cream industry, which is presently valued at about BDT 65 million (Laskar, 2017; Humayun, 2018). Due to factors including the industry's rising growth rate, the expanding middle class, changing tastes of younger consumers, the lengthening summer season, and other factors, the market is becoming more and more competitive. (Begum et al., 2020).

Gillespie et al. (2023) showed that, if excess amounts of sugar are taken by humans then it is responsible for several diseases. Due to the rise in ice cream manufacturing, the rising number of diabetic patients, and the harmful effects of sugar on human health, it was determined to do research on the development of sugar free ice cream that diabetic patients may consume.

2. Material and methods

2.1. Raw material

The ingredients needed to make ice cream, such as milk powder, pasteurized milk, sterilized cream, vanilla flavor, and stevia leaf extract, were purchased from a local market in Dhaka, Bangladesh.

2.2. Packaging material

For the purpose of packaging ice cream, ice cream cups were collected from the Dhaka local market.

2.3. Formulation of ice cream using stevia powder

The ice cream was made in accordance with the flowchart shown in Fig. 1. Following the recipe, ingredients were brought and weighed. Table 1 shows how stevia (*S. rebaudiana*) powder was used to produce ice cream in place of sugar. 91.58 g of milk powder and 848.90 g of Pasteurized milk were added in the blender (MX-AC400 Mixer Grinder, 220–240 V). We blend those mixtures for 2 min. After that, add 36.63 g of sterilized cream in a blender. In addition, 8.24 g of vanilla flavor and 14.65 g of stevia leaf extract were added in a blender for 4 min bland. The mixers were transferred in an Ice cream machine and stay 1 hour. Finally, we collect Sugar-Free Ice Cream in a cups and stored at freeze.

Table 1
Formulated Ice cream (g/kg).

Ingredients	Sugar free ice cream with Stevia
Milk powder	91.58 (g)
Pasteurized milk	848.90 (g)
Stevia	14.65 (g)
Sterilized cream	36.63 (g)
Vanilla flavor	8.24 (g)
Total	**1000** (g)

2.4. Chemical analysis

The several methods were used to investigate the chemical composition of ice cream. The International Dairy Federation's 1982 method was used to assess total solids, the IDF's 1986 Kjeldhal method was used to determine protein, ISO 488 was used to measure fat content, AOAC 2012 to calculate ash content, and ISO 6091 was used to determine the amount of titrable acidity.

2.5. Physicochemical assessments

Viscocity (NDJ-5S, Drawel, China) was measured by Atallah et al. (2022), according to Marshall et al. (2003), the freezing point was determined, a universal testing device was used to evaluate the hardness of ice cream samples. The speed for hardness test was adjusted to 60 mm/s while the trigger force was 1 N, 25% deformation and 2 s of holding time at −20 ˚C.

2.6. Sugar profile

The profiling of sugar was performed according to Arslaner et al. (2019) with some modifications. Five-grams of samples were dissolved in 20 mL of a mixture of water and methanol (75:25; v/v) and after that, centrifuged at 5000 g for 10 min at 4 ˚C. Later, the supernatant was collected and filtered using a 0.45 μm membrane filter and shifted to 2 mL HPLC vials until further analysis. The samples were then injected into HPLC system ((UltiMate® 3000 HPLC system; Dionex, Thermofisher Scientific, USA) consisted of Kromasil 100–5-NH_2 column with Heptane as mobile phase and UV detector. The column oven temperature fixed at 40 ˚C and finally, 20μL of the extract was injected. A comparison to sugar standards with retention times was used to determine the presence of glucose, fructose, galactose, sucrose, and lactose.

2.7. Microbiological properties

According to Atallah et al. (2022), the total aerobic meshophilic bacterial count and the total psychrotrophic bacterial count were assessed.

2.8. Sensory analysis

Five members of a sensory panel, ranging in age from 25 to 45, performed a sensory evaluation of the ice cream samples. The sensory characteristics, such as flavor, body texture, color and appearance, melting quality, and general acceptance, were evaluated. The 9-point hedonic scale was used to evaluate the senses (Wichchukit & O'Mahony, 2015).

Table 2
Chemical Analysis%, (g/100 g-1) of sugar free ice cream compared to other available brands in market.

Parameters	Ice cream with stevia	Brand A	Brand B	Brand C	Brand D	Brand E	Significance levels (ANOVA)
Total Solids	29.43 ± 1.56	32.87 ± 1.07	34.39 ± 0.98	35.09 ± 1.18	34.23 ± 1.26	33.98 ± 1.19	0.0013
Protein	3.74 ± 0.23	2.12 ± 0.08	2.19 ± 0.13	2.28 ± 0.09	2.40 ± 0.14	2.35 ± 0.18	<0.0001
Fat	8.42 ± 0.19	9.97 ± 0.18	9.93 ± 0.17	10.28 ± 0.16	10.25 ± 0.12	9.90 ± 0.14	<0.0001
Ash	0.82 ± 0.07	3.43 ± 0.13	3.49 ± 0.21	3.67 ± 0.12	3.54 ± 0.19	3.44 ± 0.22	<0.0001
Titrable acidity	0.19 ± 0.03	0.18 ± 0.08	0.19 ± 0.09	0.18 ± 0.07	0.18 ± 0.07	0.19 ± 0.08	0.9999

The number of sample 3 ($n = 3$); The results are presented in Mean ± SD.

Table 3
Physical analyses of sugar free ice cream compared to other available brands in market.

Parameters	Ice cream with Stevia	Brand A	Brand B	Brand C	Brand D	Brand E	Significance levels (ANOVA)
Viscocity (cP)	93.21 ± 1.98	91.78 ± 1.19	91.28 ± 1.27	90.32 ± 1.97	91.23 ± 2.01	92.26 ± 1.29	0.4253
Freezing point (˚C)	2.29 ± 0.17	3.32 ± 0.14	3.21 ± 0.18	3.35 ± 0.10	3.30 ± 0.16	3.34 ± 0.17	<0.0001
Hardness (N)	42.98 ± 3.27	46.21 ± 3.48	45.38 ± 4.22	44.97 ± 3.29	46.21 ± 3.76	43.24 ± 3.57	0.7962
Sensory test	7.54	6.95	7.29	7.33	7.12	7.15	–

The number of sample 3 ($n = 3$); The results are presented in Mean ± SD.

Table 4
Sugar Content of Stevia ice cream compared to other available brands in market% (g 100 g-1).

Parameters	Ice cream with Stevia	Brand A	Brand B	Brand C	Brand D	Brand E	Significance levels (ANOVA)
Glucose	0.23 ± 0.07	0.70 ± 0.11	0.75 ± 0.13	0.72 ± 0.10	0.74 ± 0.12	0.77 ± 0.19	0.0014
Fructose	ND	0.22 ± 0.09	0.21 ± 0.09	0.23 ± 0.08	0.22 ± 0.05	0.24 ± 0.08	–
Galactose	0.27 ± 0.08	0.30 ± 0.03	0.29 ± 0.06	0.32 ± 0.04	0.31 ± 0.09	0.29 ± 0.06	0.9431
Sucrose	ND	13.98 ± 1.24	12.92 ± 1.09	13.87 ± 1.12	12.98 ± 1.03	13.29 ± 0.98	–
Lactose	3.29 ± 0.47	3.43 ± 0.14	3.68 ± 0.19	3.85 ± 0.12	3.60 ± 0.12	3.73 ± 0.85	0.6093

*ND: Not detected; The number of sample 3 ($n = 3$);.

2.9. Statistical analysis

All experiments were replicated three times. The mean and standard deviation were used to express the data. The GraphPad Prism 8 was used to determine the ordinary one-way ANOVA for group comparison and the Tukey's multiple comparisons test for pair-wise comparison of FIC with different brands. A statistically significant level of probability was defined as $*$ is equal to $p < 0.05$, $**$ is equal to $p < 0.01$, $***$ is equal to $p < 0.001$, $****$ is equal to $p < 0.0001$ and ns is equal to nonsignificant.

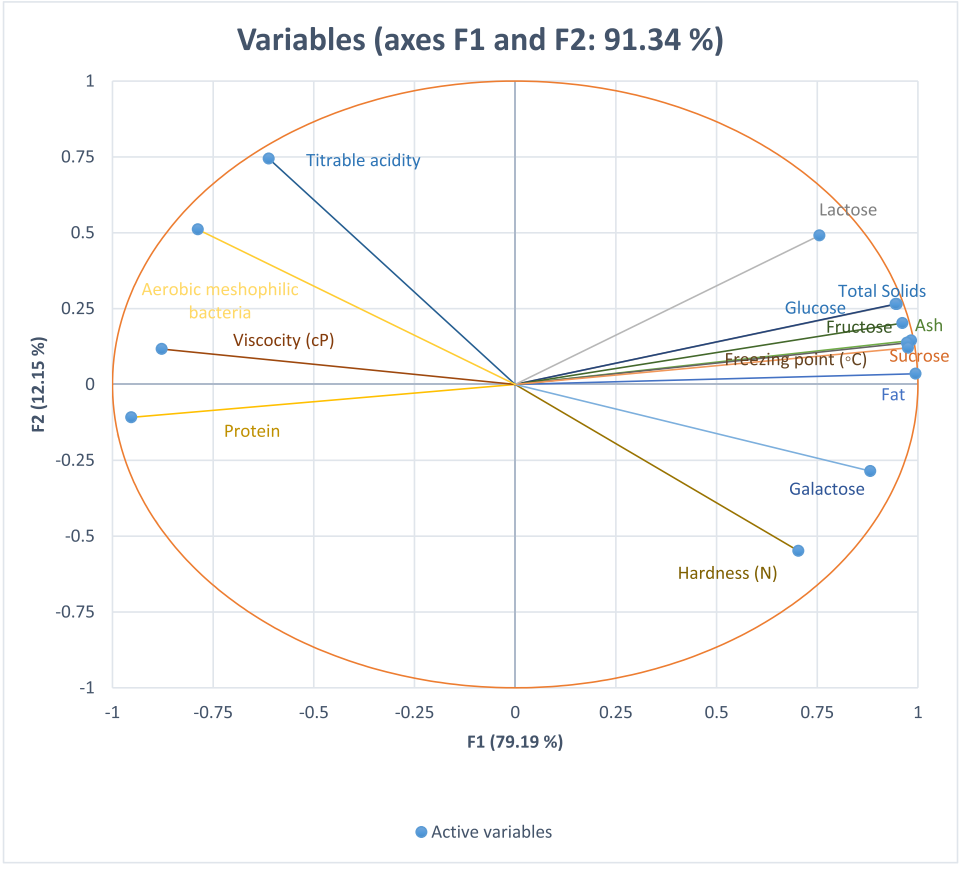
3. Results and discussions

Using natural sweeteners as an alternative to artificial sugar in ice cream and examining its chemical, physical, microbiological, and sensory qualities was the main goal of this study. These properties are important for the quality of ice cream because they have a significant impact on consumers' consumption of these products. Goff (2018) who reported ice cream contain between 9 and 28% sugar of the total components. Now, People are more conscious of their health state and careful of their food as a result of the sharp rise in type 2 diabetes in different age. The manufacture of ice cream is directly impacted by this problem (Moriano et al., 2017). Due to variations in the quantities of total solids, protein, fat, and ash in the combinations, the chemical features of the FIC and different bands of ice cream varied significantly from one another.

3.1. Chemical analysis

The inclusion of sweeteners has a significant impact on the chemical properties. Table 2 shows the chemical analysis of the ice cream. The use of natural sweeteners (stevia) had a significant ($p < 0.05$) impact on the changes in total solids, protein, fat, ash, and titrable acidity values of all samples. Firstly, the total solid in FIC was 29.43 ± 1.56% (w/w), whereas in different bands which were changed between 32.87 ± 1.07 and 35.09 ± 1.18% (w/w). According to data analysis, fat, ash, freezing point, glucose, fructose, sucrose and lactose of the ice creams were significantly positive related with the total solids, whereas the protein and viscocity were negatively linked (Table 6). Total solids of FIC are significantly ($p < 0.01$) different in several brands (Fig. 3(A)). The total amount of solid and dry components in ice cream is known as the total solids. Alizadeh et al., 2014 found that when stevia was used in place of sucrose in ice cream, there were substantial alterations in the compositional qualities. Deshmukhan et al. (2014) found similar findings, stating that the presence of stevia reduced the total solid value compared to sugar-added ice cream samples. In addition, protein content in FIC was 3.74 ± 0.23% but in different bands which were changed between 2.12 ± 0.08% and 2.40 ± 0.14% (w/w). Protein was significantly negative correlated to total solids, fat, ash, freezing point, glucose, fructose and sucrose (Table 6). On the other hand, ptotein of FIC are significantly ($p < 0.0001$) different in five brands (Fig. 3(B)). Alizadeh et al. (2014) was found when stevia used then protein content also increased. Which is directly correlated our present study. Proteins assist in emulsification, whipping, and the capacity to hold water, and they also contribute to the development of the structure of ice cream. Ice cream manufacturing requires foaming, and milk proteins are known for their capacity to produce foams. As a result, milk proteins help to stabilize the air interface in ice cream, which is crucial for the product's overall structure and structural stability (Patel et al., 2006). On the other hand, Fat value was 8.42 ± 0.19% (w/w) in the FIC sample and in different bands which were range from 9.90 ± 0.14 to 10.28 ± 0.16%. It also seen that, fat was significantly positive and negative connected to total solids, ash, viscocity, freezing point, glucose, fructose, galac-

tose, sucrose and protein Table 6. The fat of FIC are significantly ($p < 0.0001$) different in all brands (Fig. 3(C)). Deshmukhan et al. (2014) and Alizadeh et al. (2014) were found that fat content high in control sample (with sugar) than experiment sample (with stevia) which comply with our study. Fat plays a vital role as a structural agent, helps to stabilize the air phase, and produces the distinctive sensory qualities that are expected of ice cream (Méndez-Velasco & Goff, 2012; Rolon et al., 2017). It also affects the release of hydrophobic flavor molecules (McClements, 2015). Ash content in ICS was 0.82 ± 0.07% and varied from 3.43 ± 0.13% to 3.67 ± 0.12% (w/w) in all brands.



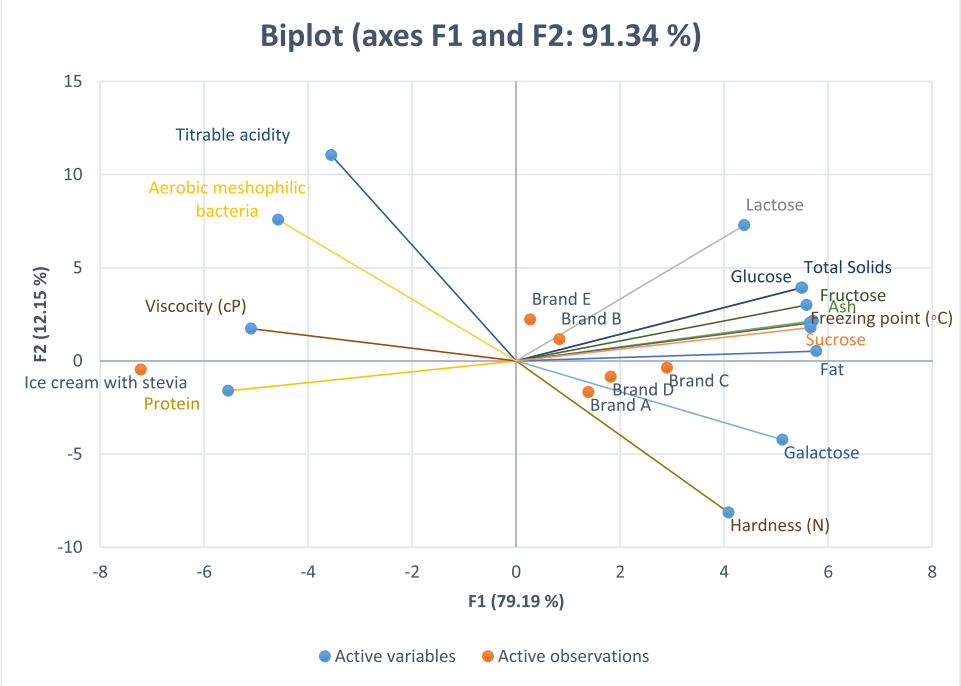


Fig 2. The representation of developed ice cream features such as chemical analysis, physical analysis, sugar content, and microbial count analysis attributes as defined by the Principal component 1 (PC1).

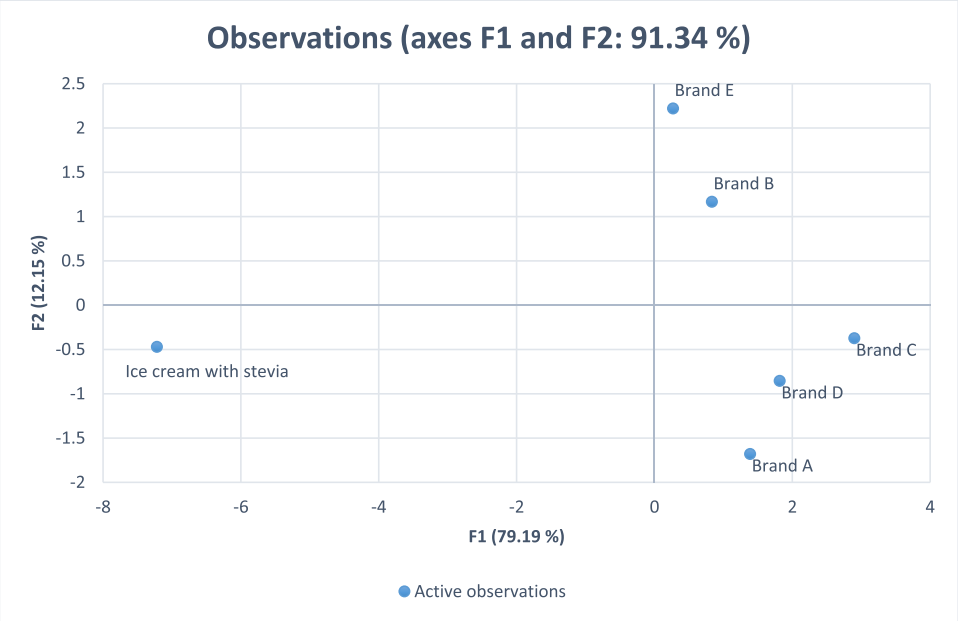


Fig 2. Continued

It was significantly positive and negative interacted to total solids, fat, freezing point, glucose, fructose, sucrose and protein shown in Table 6. Ash of FIC are significantly ($p < 0.0001$) different in several brands (Fig. 3(D)). Lastly, there was no significant difference in titrable acidity values among all samples ($p > 0.05$) show in Fig. 3(E) but with aerobic meshophilic bacteria and galactose which was significantly positive and negative interconnected (Table 6). The ice cream with stevia (FIC) contained the highest amounts of protein but lower value of total solids, ash, and fat.

3.2. Physical analyses

Viscosity had been regarded as a crucial component of ice cream formulations, and up to a certain extent, it seems necessary for whipping ability and air retention. A mixture's viscosity value is influenced by the presence of fat, protein, stabilizers, bulking agents, and high-quality components. Table 3 contains a list of all samples' viscosity levels. The viscosity level of FIC was 93.21 ± 1.98 cP but in marketed product which ware ranged from 90.32 ± 1.97 to 92.26 ± 1.29 cP. The FIC showed the highest amounts of viscosity, whereas the Brand C exhibited the lowest values. The result reveal that viscosity is significantly positive correlated with fat but it negative associated with total solids and glactose (Table 6). Fig. 4(A) represent the ANOVA test of viscosity which is not significantly different ($p > 0.05$) between FIC and other brands. According to Mayangsari et al. (2019) the stevia addition raised the ice cream samples' viscosity levels. The fiber content of the powder stevia leaf was apparently responsible for the outcome.

Table 3 provides information about the ice cream's freezing point. The freezing point of FIC was 2.29 ± 0.17 °C and marketed product which were almost same (3.21 ± 0.18 to 3.35 ± 0.10 °C). Freezing point is significantly positive connected with total solids, fat, ash, glucose, fructose and sucrose ($p < 0.05$) shown in Table 6. The substitution of sweeteners and bulking additives for sucrose had an impact on freezing point levels. On the other hand, a mixture's freezing point decreases when there is an increase in protein because it replaces water (Baer & Keating, 1987). Ptotein of FIC are significantly ($p < 0.0001$) different of all brands (Fig. 4(B))

An important aspect to consider is the product's hardness when it is at the ideal temperature for scooping or dipping. Many parameters, such as total solids, the principal melting point, the quantity and kind of stabilizers, etc., have an impact on hardness. As a result, it is optimal for all ice creams to have approximately identical overruns and melting points. When the amount of water-soluble components grew, melting and freezing values dropped. Because they have an impact on the melting and freezing points of the mixtures, the amount and type of ingredients that go into making ice cream must be carefully selected (Atallah et al., 2022). Table 3 shows the hardness values for sample. Hardness value of FIC was 42.98 ± 3.27 N but in brands ranged from 43.24 ± 3.57 N to 46.21 ± 3.76 N. The highest hardness value ware detected in the Brand A and D (46.21 ± 3.48 N and 46.21 ± 3.76 N) compared with the other Brands (B, C and E). In contrast, the lowest value (42.98 ± 3.27 N) was found in ICS. The results reveal no significantly different ($p > 0.05$, Fig. 4C) between all ice creams. Due to an increase in the ratios of total solids, fat, sucrose, and ash in the combinations, all brands have the maximum value of hardness. The degree of hardness in ice cream is affected by a number of variables, including overrun, ice crystal size, fat destabilization, ice phase volume, and the mixture's consistency properties (Muse & Hartel, 2004). Atallah et al. (2022) found that the hardness value dropped with the stevia addition compared to other ice cream samples.

The sensory characteristics of ice cream were evaluated by flavor, body and texture, color and appearance melting quality and overall acceptability. The sensory attributes of FIC and five different brands (A, B, C, D, E) were 7.54, 6.95, 7.29, 7.33, 7.12 and 7.15 respectively. The highest value of sensory attributes was found in FIC (7.54). Stevia and bulking agents are used to replace sugar in ice cream, Atallah et al. (2022) found that the sensory scores were more suitable for ice cream. In order to satisfy consumers, the ice cream market trend is shifting toward a formulation of ice cream that is free of sugar has outstanding texture, structure, and sensory qualities.

3.3. Sugar profiles

For FIC and various brands, Table 4 illustrates the sugar levels. Substitution for sugar with sweeteners for example stevia extract contain glucose and fructose show significantly positive correlation (Table 6). In FIC, Glucose content was 0.23 ± 0.07. Whereas in all brands which ware ranged from 0.70 ± 0.11 to 0.77 ± 0.19%. When compared to the other samples, the Brand E sample had the highest glucose level (0.77 ± 0.19%). Fig. 4(D) represent the ANOVA test of glucose which

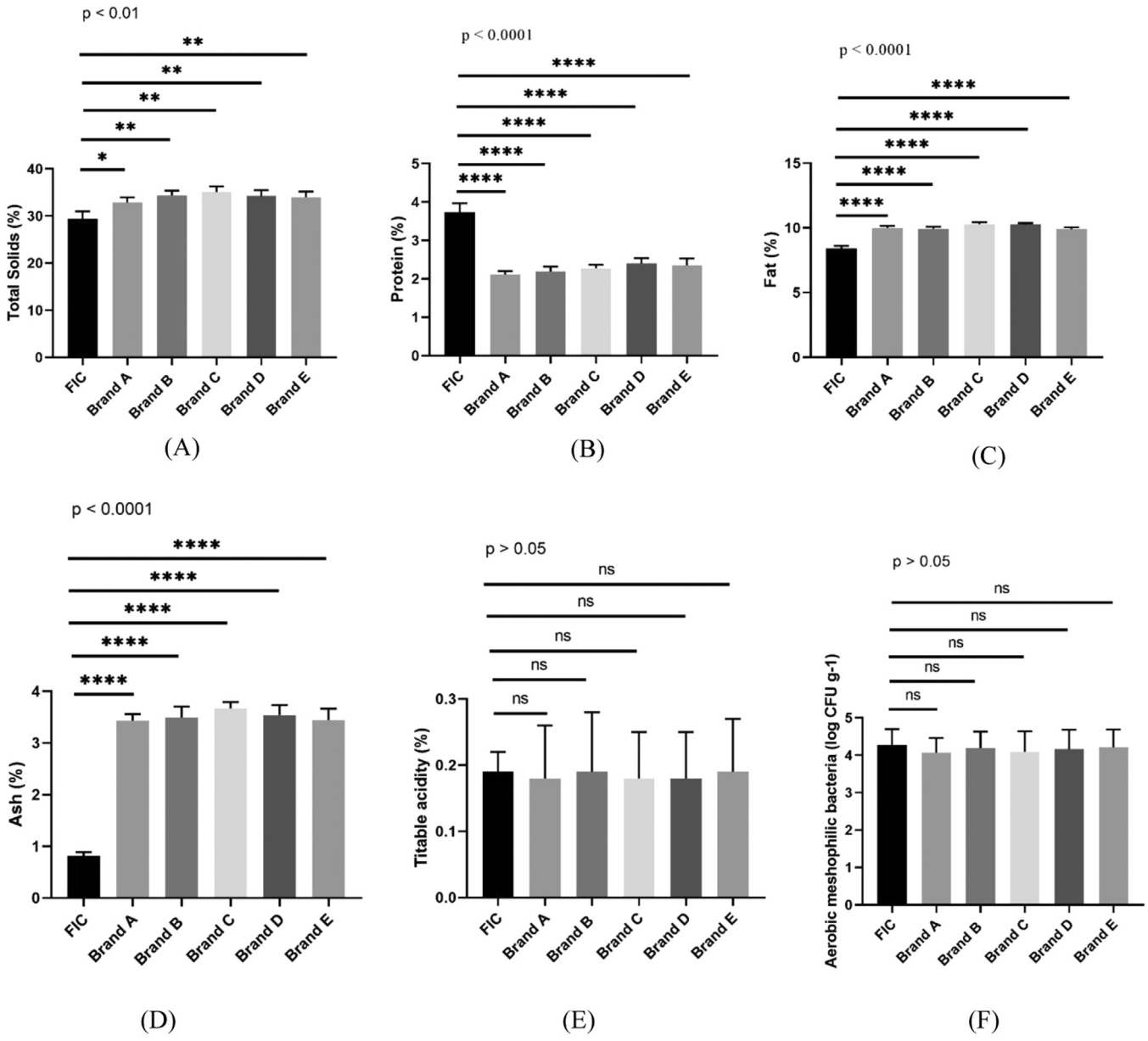


Fig 3. ANOVA test for multiple groups of Ice cream (Chemical analysis and Microbiological analyses) and the Tukey's multiple comparisons test for pair-wise comparison of FIC with different brands. A statistically significant level of probability was defined as ∗ is equal to $p < 0.05$, ∗∗ is equal to $p < 0.01$, ∗∗∗ is equal to $p < 0.001$, ∗∗∗∗ is equal to $p < 0.0001$ and ns is equal to nonsignificant.

is significantly different ($p < 0.01$) between FIC and five brands In the FIC, fructose and sucrose levels were not observed but in different bands which were range from 0.21 ± 0.09% to 0.24 ± 0.08% and 12.92 ± 1.09% to 13.98 ± 1.24%, respectively. The highest level of fructose and sucrose ware obtained in the Brand E and Brand A. Galactose and Lactose values were not changed significantly ($p > 0.05$, Fig. 4E & 4F) in FIC and all Brands (0.27 ± 0.08% to 0.32 ± 0.04% and 3.29 ± 0.47% to 3.85 ± 0.12%). Generally, all Brand (A, B, C, D, and E) contain the highest values of sucrose, glucose, fructose, galactose, and lactose whereas, FIC fructose and sucrose were not detected. This is because sucrose has been completely replaced by sweeteners (stevia). Sucrose has many disadvantages and it develop several metabolic diseases for example, coronary heart disease, type 2 diabetes mellitus, non-alcoholic fatty liver disease, Obesity and so on (Gillespie et al., 2023). For diabetic patients, natural sweetened (Stevia) ice cream may be an alternative. Recent years have seen the rise of a number of healthy trends in dairy products as a result of the rising incidence of diabetes, obesity, and other health-related problems worldwide. The demand for healthy products from consumers has sparked innovation and resulted in the creation of a number of healthy substitutes for ingredients currently used by the dairy industry (Alizadeh et al., 2014).

3.4. Microbiological analyses

Table 5 shows the total numbers of aerobic mesophilic and psychrotrophic bacteria. Total aerobic mesophilic bacteria counts were significantly positive recorded ($p > 0.05$) with titrable acidity shown in Table 6. The total number of aerobic mesophilic bacteria is nearly the same ($p > 0.05$, Fig. 3F). In FIC was 4.27 ± 0.43 log 10 CFU g-1 but in all Brands ranged from 4.07 ± 0.39 log 10 CFU g-1 to 4.21 ± 0.48 log 10 CFU g-1. The count of total psychrotrophic bacteria in all samples ware < 1 log10 CFU g-1. These findings are comparable to those of

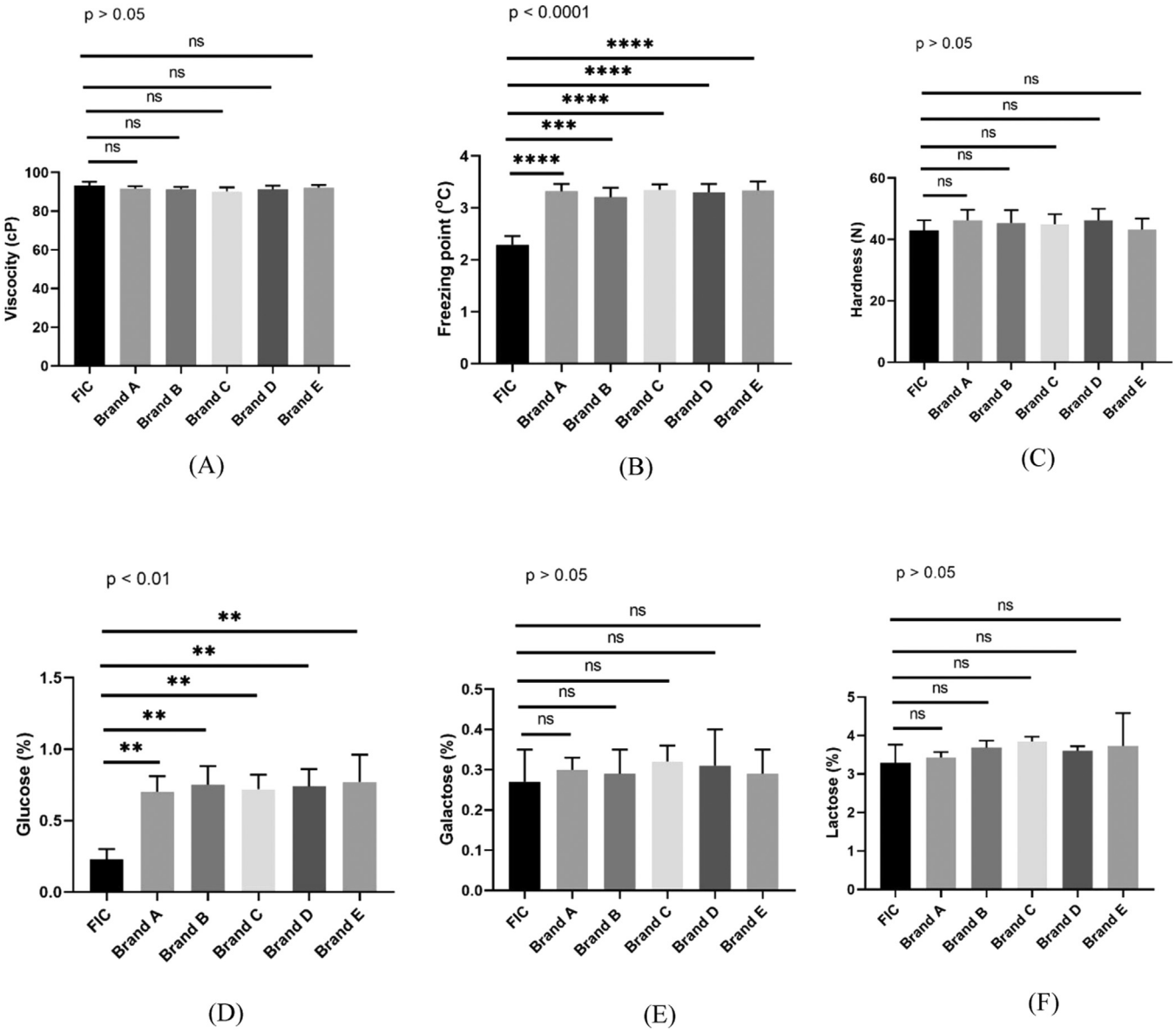


Fig 4. ANOVA test for multiple groups of Ice cream (Physical analysis and Sugar content) and the Tukey's multiple comparisons test for pair-wise comparison of FIC with different brands. A statistically significant level of probability was defined as ∗ is equal to $p < 0.05$, ∗∗ is equal to $p < 0.01$, ∗∗∗ is equal to $p < 0.001$, ∗∗∗∗ is equal to $p < 0.0001$ and ns is equal to nonsignificant.

Table 5
Microbiological analyses (log 10 CFU g-1) of Ice cream with stevia compared to other available ice cream brands in Market.

Bacteria	Ice cream with Stevia	Brand A	Brand B	Brand C	Brand D	Brand E	Significance levels (ANOVA)
Aerobic meshophilic bacteria	4.27 ± 0.43	4.07 ± 0.39	4.19 ± 0.44	4.10 ± 0.54	4.16 ± 0.52	4.21 ± 0.48	0.9952
Psychrotrophic bacteria	<1	<1	<1	<1	<1	<1	–

The number of sample 3 ($n = 3$); The results are presented in Mean ± SD.

Atallah et al. (2022) who investigated the effects of several sweeteners (sucrose, stevia, sucralose, and sorbitol) on ice cream.

3.5. PCA analysis

Fig. 2 shows Principal component analysis (PCA) was employed in the present work to figure out the most important characteristics of the developed and five brand ice cream samples through chemical analysis, physical analysis, sugar content, microbial count, and sensory analysis. Based on the multivariate analysis, the first two principal components described 91.34% of the variations among ice cream samples. Following the findings, two PCs presented 91.34% of the variation of the input variables, associated with a significant contraction of the data with major contributions of 79.19% for the first principle component and 12.15% for the second principle component. In accordance with the content, PC1 (the main component) was largely attributed to the measurements of total solids, protein, fat, ash, viscocity, freezing point, hardness, glucose, fructose, galactose, sucrose, lactose, Aerobic meshophilic bacteria except titrable acidity, and PC2 (supplementary PC) was associated to titrable acidity in the ice cream datasets.

Table 6
Correlation coefficients among Chemical Analysis, Physical analysis, Sugar Content and Microbial Count.

Variables	Total Solids	Protein	Fat	Ash	Titrable acidity	Viscocity	Freezing point	Hardness	Glucose	Fructose	Galactose	Sucrose	Lactose	Aerobic meshophilic bacteria
Total Solids	1													
Protein	−0.894*	1												
Fat	.956**	−0.940**	1											
Ash	.956**	−0.979**	.985**	1										
Titrable acidity	−0.392	0.443	−0.594	−0.478	1									
Viscocity	−0.876*	0.743	−0.860*	−0.803	0.631	1								
Freezing point	.927**	−0.972**	.974**	.992**	−0.495	−0.752	1							
Hardness	0.525	−0.675	0.690	0.643	−0.744	−0.661	0.605	1						
Glucose	.943**	−0.968**	.955**	.988**	−0.360	−0.722	.983**	0.572	1					
Fructose	.934**	−0.971**	.966**	.991**	−0.437	−0.735	.998**	0.569	.991**	1				
Galactose	0.806	−0.707	.876*	0.789	−0.834*	−0.916*	0.781	0.664	0.699	0.749	1			
Sucrose	.925**	−0.989**	.971**	.995**	−0.486	−0.764	.996**	0.641	.983**	.993**	0.767	1		
Lactose	.904*	−0.669	0.763	0.766	−0.160	−0.775	0.740	0.145	0.763	0.761	0.675	0.723	1	
Aerobic meshophilic bacteria	−0.572	0.744	−0.735	−0.703	.846*	0.710	−0.719	−0.766	−0.602	−0.674	−0.804	−0.737	−0.329	1

Conclusion

The qualities of the ice cream could be affected by how it is made from different components. As a result, it should be understood that the formulation and ingredient selection are crucial to the success of ice cream production. The impact of sweeteners (stevia) on the chemical, physical, microbiological, and sensory aspects of ice cream was investigated in this study. On the other hand, compared FIC with other five different brands (A, B, C, D, and E). Using stevia as a natural sweetener has a favorable effect on the creation of ice cream. The results of the current study suggest that selling ice cream to people with diabetes could be successful if natural sweeteners (stevia) are used. Hence, the ice cream market is shifting toward a sizable market for sugar free ice cream as well as formulations with outstanding texture, structure, and sensory qualities to obtain consumer pleasure. The risk of diseases may be decreased if natural sweeteners are used in place of sucrose when making ice cream.

Ethical statement

The authors declare that the material is the authors' own original work, which has not been previously published elsewhere. The work is not currently being considered for publication elsewhere. The participants provided their oral consent to participate in this study.

Declaration of Competing Interest

The authors declare no conflicts of interest.

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