

Formulation and Quality Assessment of Vegan Ice Cream from Avocado and Wheat Milk

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Abstract

Plant based foods are widely consumed due to their health benefits. These foods are excellent substitutes due to their high concentrations of micronutrients, antioxidants, and bioactive compounds which are linked to a reduction in noncommunicable diseases. The present study was carried out with the objective of evaluating the physicochemical and sensory parameters of vegan ice-cream. The control sample was formulated using whipping cream, sugar and vanilla essence. Experimental product was developed using wheat milk, avocado puree, watermelon seeds powder and vanilla essence. Both the products were analyzed for pH, total solids, titrable acidity, melting rate and overrun. The product was also subjected to sensory evaluation to determine its acceptability by 15 semi trained panelists. The results showed that the pH was slightly higher for control product (6.64 ± 0.01) than that of experimental (6.13 ± 0.03). Total solid content was shown to be 38.6% which was lower than the control product (46.5%). Melting rate for control sample showed no observable melting after 1 hour indicating good textural stability. Overrun quality of control sample was indicated to be 16.5% while, for experimental it was slightly higher with 17.5%. Sensory analysis revealed that the control sample scored higher than the experimental sample. Statistically significant differences were noted for appearance ($p=0.02$) and taste quality ($p=0.0009$). However, flavor and overall acceptability showed no significant differences suggesting that the experimental formulation remained generally acceptable to panelists despite slight variations. Overall, the study concludes that a product with acceptable physiochemical characteristics, and desirable sensory quality could be developed by utilizing plant-based sources. Such products would serve as a promising alternative to conventional dairy ice cream which also aligns with the present-day consumers demand for health promoting products.

KeyWords: Vegan, Sensory, Micronutrients, Antioxidants.

1. Introduction

Ice cream is a delicious, tasty, and nutritious frozen treat consumed worldwide by individuals. Generally, ice cream is prepared using dairy ingredients such as cream, milk, and sugar (Legassa, 2020). However, currently there is a increased consumer awareness about health, environmental sustainability, and ethical concerns linked to the utilization of animal products has led to a growing demand for plant-based alternatives, including vegan ice cream. Vegan ice cream is formulated without any animal-derived ingredients and instead uses plant-based substitutes such as almond milk, soy milk, coconut milk, wheat

milk, oat milk, or nut-based emulsions to mimic the texture and sensory properties of conventional dairy ice cream (Towid Hasan, 2023 December 15). The growing prevalence of lactose intolerance, milk allergies, and the increasing adoption of vegan and vegetarian diets have significantly boosted the demand for plant-based frozen desserts. Plant-derived milk alternatives allow the development of dairy-free frozen products that are free from cholesterol and suitable for individuals with specific dietary needs. Furthermore, depending on the plant source, these alternatives may offer additional

nutritional benefits, including unsaturated fatty acids and various bioactive compounds (Hatice Bekiroglu, 2022). Despite the growing popularity of vegan ice cream, several challenges remain in achieving the same texture, creaminess, and flavour profile as traditional dairy ice cream. Issues such as lower protein content, potential off-flavour, and differences in melting behaviour must be addressed through appropriate formulation strategies and ingredient optimization. Therefore, research on vegan ice cream focuses on improving its nutritional value, sensory quality, and technological properties while maintaining consumer acceptability (Ana Leahu, 2022). Due to the increasing demand for sustainable and dairy-free frozen desserts, vegan ice cream has attracted considerable attention from both the food industry and academic researchers. Therefore, the present study focuses on the formulation and evaluation of vegan ice cream prepared from plant-based ingredients, with emphasis on improving its physicochemical and sensory characteristics.

2. Methodology

The ingredients used for preparing Vegan Ice cream were sugar, watermelon seeds, vanilla essence and avocado were procured from local market and super market.

2.1.Extraction of wheat milk

Whole wheat grain was procured from the local market. The grains were cleaned, washed and soaked in water for 8-10 hours. The water was drained and the grains were ground using a kitchen blender. The ground paste was passed through muslin cloth. The milk thus collected was kept in refrigerator until further use [1-5]. The present study has been divided into two phases. Phase-1 comprised standardization and preparation of the ice cream and sensory analysis. In Phase-2, developed products were subjected to Physio-chemical analysis using standard protocols.

2.1.1. PHASE-1

In this phase, control and experimental product was standardized and prepared. Further, the product was subjected to sensory analysis to determine the acceptability by 15 semi trained panelists.

- Preparation of Control Ice-cream

The ingredient used in the control product were: whipping cream, sugar powder and vanilla essence. Chilled whipping cream was taken in a clean bowl

and beaten using a hand beater until it became light and slightly fluffy. Powdered sugar was gradually added during beating and mixed well to obtain a smooth and homogeneous mixture. A few drops of vanilla essence were then added to enhance the flavor and aroma. The mixture was gently mixed again to ensure even distribution of the ingredients. The prepared mixture was transferred into a bowl and kept in a freezer at -4°C for hardening. The frozen product was used for all the evaluations.

Preparation of experimental ice-cream

The ingredient used in the experimental ice-cream preparation were: wheat milk, avocado puree, sugar powder, watermelon seeds powder and vanilla essence. Initially, freshly prepared wheat milk was heated on a low flame to remove raw nutty flavor and to modify its texture for facilitating easy whippability. The cooked wheat milk slurry was added to a clean mixing bowl followed by avocado puree. Addition of avocado puree incorporates natural creaminess and thus improves the texture of the mixture. Both wheat milk slurry and avocado puree were blended for 5 min and powdered sugar was gradually incorporated and mixed thoroughly using a hand beater until it dissolved completely. Further, watermelon seed powder was added slowly while continuously beating to ensure uniform distribution. A few drops of vanilla essence were then added to improve the flavour and aroma. The mixture was beaten further with the hand beater until a smooth and homogeneous consistency was obtained. The mixing was repeated for 4 times to obtain a product having smooth and creamy texture. After each cycle of beating and mixing the sample was frozen for 1 hour. Finally, the prepared vegan ice cream was transferred into an airtight container and frozen at -4°C until it hardened. The sensory acceptability of the product was assessed by 15 semi-trained panel members using a 9-point hedonic scale. The score card rating scale representing quality grade description was as follows; Dislike extremely:1, Dislike very much:2, Dislike moderately:3, Dislike slightly:4, Neither like nor dislike: 5, Like slightly:6, Like moderately:7, Like very much:8, Like extremely:9. All the chemicals used in the study were of analytical grade. Distilled water was used for all the analysis and all the estimations were carried out

in duplicates.

2.1.2. PHASE-2

In this phase, both control and experimental products were subjected to physio-chemical analysis such as determination of pH, Titrable Acidity, Melting rate, overrun and total solids. The microbial analysis was also carried out for both control and experimental product to determine the yeast and mould count. The physio-chemical analysis and microbial analysis was carried out in duplicates for each set of experiments.

Physicochemical Parameters Analysed

Overrun

Percentage overrun of ice cream was determined by the gravimetric method given by National Dairy Development Board (2001). Initial weight of ice cream cup with mix was taken as W1. Final weight of ice cream cup after freezing was taken as W2. Result was expressed by using the formula:

$$\% \text{ Overrun} = (W1 - W2) \div (W2) \times 100$$

Melting Rate

The meltdown was quantified by determining the mass that drips from the product through a mesh screen as a function of time when the product is allowed to melt while being held at a selected temperature (Pon.S.Y., 2015).

Acidity

The acidity of ice cream was determined as lactic acid for Control and Citric acid for the experimental product by titrimetric method (Ranganna, 2000).

Total solid

Total solid content was determined by using the gravimetric method (National Dairy Development

Board,2001). The initial weight of an empty petri dish was taken as W. 2g of ice cream sample was taken and weighed as W1. It was then heated in a water bath until it appeared dry and then placed in hot air oven at a temperature of 1000 C for 3 hrs.The dried sample was then cooled and weighed again as W2. Result was expressed by the following Formula : % Total Solid = $W - W2 \div W1 - W \times 100$

pH

The pH of the sample was determined using a calibrated pH Meter. The instrument was first calibrated with buffer solutions of pH 4.0, 7.0 and 9.0. A small quantity of the sample was taken in a clean beaker and the electrode was immersed into the sample. The reading displayed on the meter was recorded once it stabilized (Nielsen, 2017).

Microbial Analysis

The sample was serially diluted using sterile distilled water. A measured volume of the diluted sample was poured onto sterile plates containing Nutrient Agar using the pour plate method. The plates were incubated at 25–28 °C for 3–5 days to allow growth of yeasts and molds. After incubation, the colonies were counted and expressed as colony forming units (CFU) per gram of sample (Westhoff, 2008). Statistical analysis The data were analyzed to obtain mean and SD values using Excel software. Sensory data was analyzed by t-test using data analysis tool pack to determine the significant differences between the samples shown in Table 1.

Table 1 Mean Sensory Scores of control and experimental ice cream samples

Attributes	Control	Experimental	p- Value
Appearance	8.4±0.8	8.0±0.82	0.02**
Taste	8.53±0.5	7.53±0.96	0.0009***
Texture	8.2±0.75	7.93±1.0	0.3 ^{ns}
Flavor	8.27±0.68	7.87±1.09	0.2 ^{ns}
Mouthfeel	8.33±0.87	7.87±1.02	0.2 ^{ns}
Overall acceptability	8.4±0.49	7.93±1.0	0.1 ^{ns}

The sensory evaluation of control and experimental ice cream samples was performed using a 9-point hedonic scale and the results are presented in table 1. The control sample obtained slightly higher scores for appearance (8.4 ± 0.8) and taste (8.53 ± 0.5) compared to the experimental sample (8.0 ± 0.82 and 7.53 ± 0.96), showing significant differences ($p < 0.05$). Similar trends have been reported in other vegan ice cream related experimental investigations in which, the plant-based formulations exhibited minor variations in taste and appearance as compared with conventional dairy ice cream. However, texture, flavor, mouthfeel, and overall acceptability did not indicate significant differences ($p > 0.05$), suggesting that both the products had comparable sensory quality. The overall acceptability score (7.93 ± 1.0) suggests that the experimental vegan ice cream was still well accepted by the panelists. These findings align with previous research reports showing good consumer acceptability of plant-based ice cream alternatives (Ranadheera, 2018) shown in Figure 1.

sensory parameters such as appearance and taste respectively indicating a stronger preference probably due to the presence of dairy fat and its contribution to rich flavour. However, the experimental ice cream was demonstrated to have comparable scores for body/texture, flavor, mouthfeel, and overall acceptability. Thus, it could be said that, plant-based ingredients are highly effective in mimicing many sensory characteristics of conventional ice cream. Similar findings have been reported in studies involving the formulation of plant-based frozen desserts in which, the addition of dairy alternatives effectively produces acceptable texture and mouthfeel despite minor differences in taste perception. From the above results, it could be inferred that it is possible to develop vegan ice cream having good consumer acceptance along with maintaining sensory properties close to traditional products (Ranadheera C. a., 2018) [6-10].

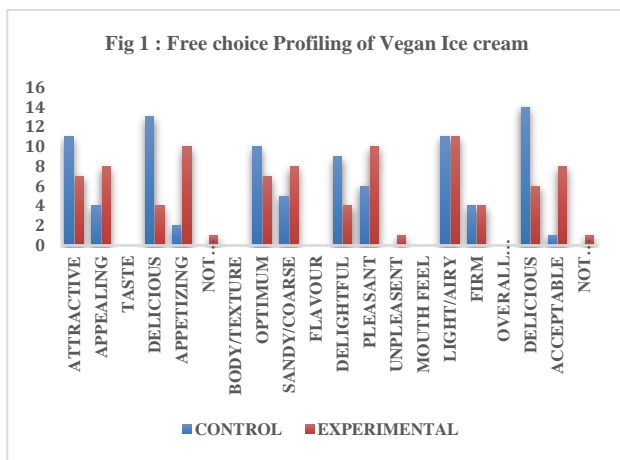


Figure 1 Free Choice Profiling of Vegan Ice-cream

Fig 1 shows the objective evaluation of control and experimental ice cream samples using free choice profiling technique. Free Choice Profiling (FCP) demonstrated noticeable sensory differences between the control and experimental ice cream samples across all the selected key attributes such as appearance, taste, body/texture, flavor, mouthfeel, and overall acceptability. The control ice cream received slightly higher scores, particularly for

Table 2 Determination of pH of control and experimental ice cream samples

pH	Mean±SD
Control	6.64±0.01
Experimental	6.13±0.03

The data pertaining to pH of iccream samples is given in table 2. The pH analysis showed that the control ice cream had a pH of 6.64 ± 0.01 , while the experimental ice cream exhibited slightly lower pH of 6.13 ± 0.03 . The lower pH in the vegan icecream sample could be attributed to the presence of plant-based ingredients, which can increase acidity compared to dairy formulations. Similar results have been reported in vegan ice cream studies where plant-based formulations showed pH values around 5.7–6.2, slightly lower than conventional icecream samples. This finding is in confirmation with the previous studies performed on vegan icecream formulations (Shin, 2022).

Table 3 Determination of Titrable acidity of control and experimental ice cream samples

Titrable Acidity	Values
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Control	0.18±0.025
Experimental	0.19±0.05

A perusal of table 3 provides information about the titratable acidity of the icecream samples. The titratable acidity of the control ice cream was 0.18 ± 0.025 , while the experimental ice cream showed a slightly higher value of 0.19 ± 0.05 . The small increase in acidity in the vegan sample might be possibly due to the presence of plant-based ingredients that can have a great bearing on the total amount of natural acid content. Other studies on plant-based ice creams have reported titratable acidity values ranging between 0.25–0.27%, indicating that vegan formulations may show comparatively higher acidity than conventional ice cream. The obtained values are shown to be within the acceptable range that are reported for frozen desserts [11-15].

- **Melting Rate**

The analysis of melting rate showed that the control ice cream exhibited no melting after 1 hour, which is an indicator of higher structural stability. In contrast, the experimental vegan ice cream showed a melting rate of 0.24 g after 1 hour suggesting that experimental product also had better texture and structural stability. In a vegan-based ice cream study, it has been reported that, vegan formulations melt faster due to the absence of dairy fat networks which is very essential for stabilizing ice cream structure. Research investigation on vegan frozen desserts have highlighted that ingredient composition and fat destabilization are known to significantly influence meltdown characteristics. Therefore, in the present investigation, the observed melting rate of the experimental sample is consistent with previous works conducted on melting behavior of plant-based ice creams (Jelena zagorska, 2024)

Table 4 Determination of over run of control and experimental ice cream samples

Overrun	Values
Control	16.5g
Experimental	17.5g

The results of the overrun quality of icecream samples is compiled in table 4. Comparing overrun values helps to determine how vegan-based ingredients influence air incorporation and structural stability relative to control ice cream. The overrun analysis showed that the control ice cream had an overrun value of 16.5 g, while the experimental vegan ice cream exhibited a slightly higher value of 17.5 g, which is suggestive of slightly greater air incorporation in the plant-based formulation. Higher overrun in vegan ice cream could be due to the emulsifying and stabilizing effects of plant components such as avocado puree and wheat milk. A study on vegan frozen desserts has reported slightly higher overrun values since, plant-based ingredients tend to improve foam stability. These results are consistent with previous documented research which states that it is possible to achieve overrun levels similar to conventional dairy ice cream when the formulations properly formulated with ingredients which would help to incorporate all the desirable qualities (Joanna Markowska, 2023)

Table 5 Determination of total solids content in control and experimental ice cream samples

Total Solids	Values
Control	46.5%
Experimental	38.6%

The results of total solids content of icecream samples is projected in table 5. Total solids analysis was carried out for both the control and the experimental samples to determine the total amount of solid components present in the formulation. The total solids content of the control ice cream was shown to be 46.5%, while the experimental sample was noticed to have 38.6% total solids. The lower total solids in the vegan sample could be due to the higher moisture content of plant-based ingredients. In a study on plant-based frozen desserts it has been reported that the total solids values ranged from 31–39%, depending on the type of plant milk used. Therefore, the total solids content of the experimental sample falls within the typical range reported for

vegan ice cream formulations (Su-yeong Hwang, 2024)

Table 6 Determination of microbial quality of control and experimental ice cream samples (CFU/g)

Method	Control	Experimental
Pour Plate Method	1X10 ⁵	1.2X10 ⁵
Streak Plate Method	1X10 ⁵	1.3X10 ⁵

The results of microbiological quality of ice cream samples is shown in table 6. the colonies were counted and are reported as CFU/g. Yeast and mould count was determined for both control and experimental ice cream to evaluate the microbial quality and shelf stability of the products. This analysis helps to ensure whether both dairy and plant-based ice cream samples meet acceptable microbiological safety standards. The yeast and mould count of the control ice cream was similar in both pour plate and streak plate technique (1X10⁵ CFU/g). While the experimental vegan ice cream it was 1.2X10⁵ CFU/g according to pour plate and 1.3X10⁵ CFU/g by streak plate. The slightly higher count in the vegan sample could be due to the natural microflora present in plant-based ingredients such as Avocado and Wheat. However, the counts remained very low indicating good microbial quality of both samples. Studies on vegan ice cream have reported low yeast and mould counts that were within acceptable limits for frozen desserts (Mendonca, 2022).

Conclusion

The ingredients used in the formulation could be said to have played a vital role in enhancing the quality of ice cream. Addition of wheat milk and avocado puree possibly would have contributed to obtain a product having rich creaminess, smooth texture, and desirable degree of mouthfeel due to their fat or fat-like functionality. Overall, the combined ingredients helped achieve desirable physicochemical stability and higher sensory acceptability. The physicochemical parameters such as pH, titratable acidity, overrun, melting rate and total solids were

found to be within acceptable limits, indicative of good product stability and suitability of the plant-derived ingredients in vegan icecream formulation. Overall, the study concludes that vegan ice cream can be successfully developed with acceptable physicochemical characteristics and good sensory quality and could be regarded as a promising alternative to conventional dairy ice cream.

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