Annals of Phytomedicine 12(1): 648-654, 2023

DOI: http://dx.doi.org/10.54085/ap.2023.12.1.90

Annals of Phytomedicine: An International Journal
http://www.ukaazpublications.com/publications/index.php

Print ISSN : 2278-9839 Online ISSN : 2393-9885

Original Article : Open Access

Efficacy of pigmented rice and its bioactive compounds on the organoleptic assessment of functional ice cream during storage

Saloni, Dinesh Chandra Rai◆, Raj Kumar Duary and Subhadip Manik*

Department of Dairy Science and Food Technology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, Uttar Pradesh, India

**Dairy Technology Division, ICAR-National Dairy Research Institute, Karnal-132001, Haryana, India*

Article Info

Article history
Received 18 April 2023
Revised 8 June 2023
Accepted 9 June 2023
Published Online 30 June-2023

Keywords
Anthocyanin
Encapsulated
Formulation
Optimized
Sensory attributes

Abstract

Pigmented rice such as black, red, and brown has nutraceutical qualities because it contains substantially more bioactive components than regular white rice. Currently, there is a greater emphasis on the use of black rice powder (BRP) in novel product formulations. Black rice powder had a moisture content of 10.75% db, with carbohydrates accounting for the majority of its dry matter (74.41%). The protein content was 8.37%, and the fat content was 2.48%, respectively. In addition, the total phenolic content (TPC) of BRP was 473.6 mg gallic acid equivalent/100 ml and showed 55.75% free radical scavenging activity (DPPH inhibition %). The total anthocyanins content was 130.2 mg cyanidin-3-glucoside/100 g. The present study was carried out to assess the changes in sensory attributes of ice cream during their storage of 90 days at 15 days intervals. Ice cream was kept at –18 ± 2°C during their storage. The sensory properties, including body and texture, color and appearance, flavor, and mouthfeel of different formulations of ice cream samples were evaluated. It was analyzed that sample A2 (ice cream mix formulated with the addition of 2% encapsulated anthocyanin powder) showed the highest sensory score in terms of body and texture, color and appearance, flavor, and mouthfeel. This can be attributed to the amount of black rice powder (BRP) and encapsulated anthocyanin powder added to ice cream mixes and increasing the antioxidative properties. No differences were found for all the sensory scores up to the 45 days of storage in both the control and optimized ice cream samples. After 45 days of storage, a decrease in sensory scores was observed.

1. Introduction

To address consumer concerns, the dairy industry has developed various low-calorie, low-fat ice cream products in recent years. However, the quality aspects of these products sometimes do not meet consumer expectations. Compared with traditional ice creams, products formulated with low-calorie and low-fat content offer a less favorable flavor and degenerative texture. This current study was carried out with the aim of enhancing the nutritional and functional properties of normal ice cream by incorporating encapsulated anthocyanin, an oxidative compound extracted from black-pigmented rice. The antioxidant activity of anthocyanin is mainly conjugated to the concentration and the hydroxylation degree of the phenolic compound and color reading characteristics showed that black rice powder has a purple color, making it a valuable technological ingredient in different dairy-food applications (Wattananapakasem *et al.,* 2021). Antioxidants can lower oxidative stress in the body by destroying reactive oxygen species and protecting or healing tissue damage (Saloni *et al.,* 2022). Ice cream is a tasty, healthy, and nourishing frozen dairy product. It is commonly consumed throughout the world and is well-liked by all age groups because of its deliciousness and nutrient-dense nature (Karthikeyan *et al.,* 2014; Patel *et al.,* 2022). It is commonly consumed worldwide and is well-liked by all age groups because of its deliciousness and nutrient-dense nature (Saloni *et al.,* 2020). Due to the high demand from consumers, ice cream and other dairy products have been enhanced with various bioactive compounds extracted from herbs, prebiotics, probiotics, and vitamins (Singh *et al.,* 2022; Sharma and Sarwat, 2022). According to Spence, ice cream could be considered a viable option for supplying nutrition to elderly patients (aged > 60 years) in hospitals and senior living facilities. These studies strongly suggest that ice cream might be useful for supplying extra protein to combat prevalent malnutrition (Roy *et al.,* 2022). Additionally, ice cream is found as a robust food matrix with numerous physical phases. If, one component is eliminated, it could have an impact on the product's sensory qualities and other physical features that customers might find essential (Rolon *et al.,* 2017). The producer does not affix an expiration date to ice cream products since they are sterilized during production and kept at a temperature of –18 ± 2°C. Furthermore, according to Codex requirements, declaring the expiration date on ice cream is optional in the United States of America, the European Union, and other nations. Despite being kept in a frozen form, ice cream can be a suitable source for microbial development because of its food

Corresponding author: Dr. Dinesh Chandra Rai
Professor, Department of Dairy Science and Food Technology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, Uttar Pradesh, India
E-mail: dcrai@bhu.ac.in
Tel.: +91-9415256645

content (milk protein, fat, and lactose), neutral pH, and long shelf-life. There is a risk of microbial development during processing following pasteurization because of the addition of contaminated components or inappropriate handling of the finished goods, including incorrect storage temperature. Ice cream is particularly dangerous for immune-compromised patients, children, and the elderly since it can spread foodborne infections to them. As an illustration, *Listeria monocytogenes* has recently been connected to a number of foodborne outbreaks that have been linked to various contaminated ice creams. Therefore, specific indicators that can determine the shelf-life of ice cream goods are required in order to determine an expiry date (Park *et al.,* 2018). The present study was carried out to evaluate the changes in sensory attributes of ice cream during their storage of 90 days (–18 ± 2°C) at 15 days intervals.

2. Materials and Methods

2.1 Preparation of control and optimized ice-cream

Different treatments of ice cream mixes were prepared in triplicate batches as follows: control-contain milk (@ 4.5% fat), sugar (15%), skim milk powder (SMP), cream (@40% fat), stabilizer emulsifiers, and compared with ice cream mix prepared by replacing SMP with BRP. The basic ice cream mix was produced based on the food safety and standard authority of India (FSSAI) standards of ice cream. The formulated ingredients were mixed and dissolved for 2 h at room temperature and then preheated at 60°C for 5 min and homogenized at 2500 psi. The formulations were pasteurized at 85 ± 1°C for 15 min and then transferred to ageing vat at 4°C for 6-12 h. The mixtures were then frozen for 20 min in a continuous freezer. The ice cream samples were packed into plastic containers (100 ml), and stored at – 18 ± 2°C until analysis (Figure 1).

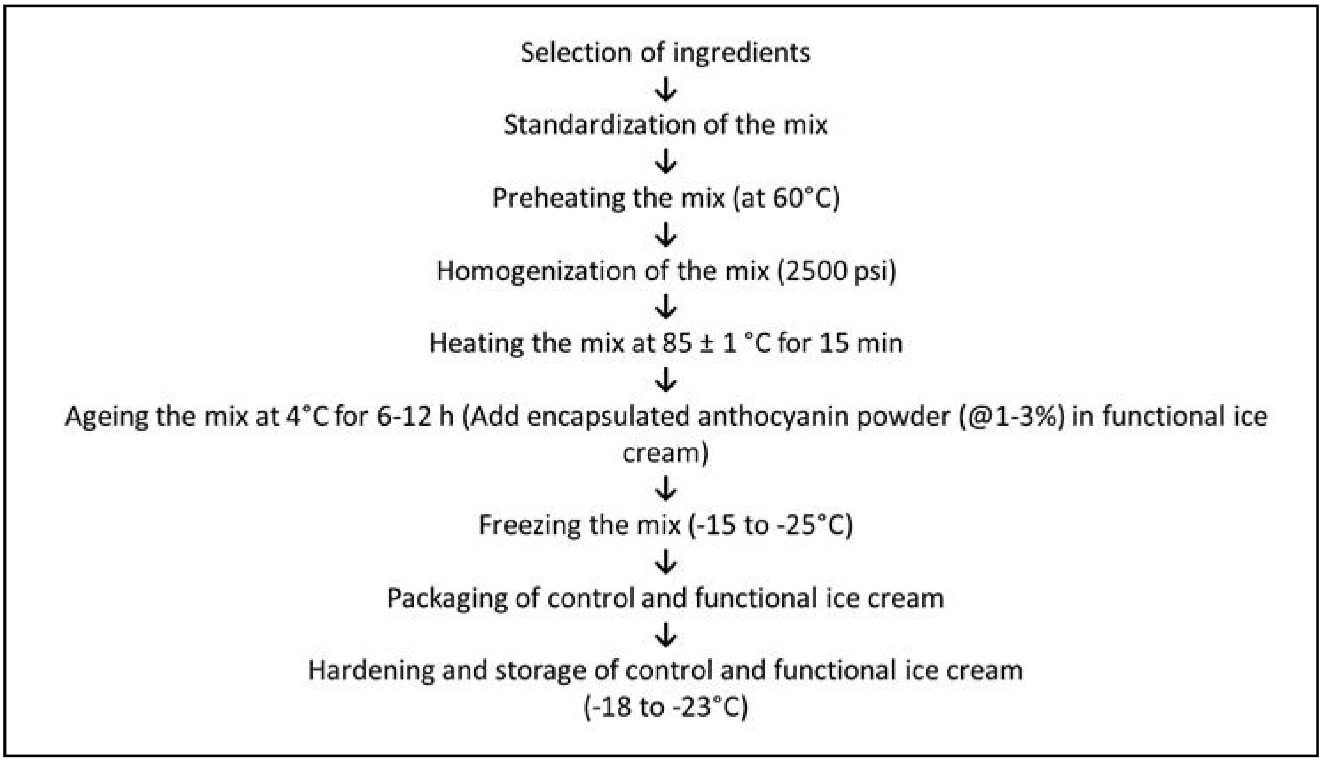

Figure 1: Flow diagram of control and functional ice cream formulation.

2.2 Sensory evaluation

Sensory attributes of ice cream samples was evaluated with some modifications (Roy *et al.,* 2022). A panel of ten semi-trained panellists with sufficient understanding of ice cream quality received the ice cream samples for sensory evaluation in 100 ml polystyrene cups. The ice cream samples were assessed for various sensory attributes: color and appearance, flavor, body and texture, and mouthfeel characteristics. A Hedonic scale from 1 to 9 was used. Scale 1 refers to extreme dislike, and Scale 9 refers to extreme liking. The overall score of the evaluated qualities was used to compute overall acceptability. Color and appearance attribute was considered to assess the sample's color uniformity. The flavor attribute was evaluated to check flavor and the presence of an off-flavor in the ice cream samples. Body and texture attribute was evaluated for gumminess, sogginess, fluffy body, sandiness, coarse/iciness, crumbly and weak body in the samples. The mouthfeel attribute was assessed to predict the overall liking of ice cream during eating.

2.3 Statistical analysis

One-way ANOVA was used to analyse the information gathered throughout the experiment (analysis of variance) using SPSS software, version 17.0 (SPSS Inc., Chicago, IL). A post hoc Tukey test was applied when the homogeneity of variances was assumed and the significance was taken at 95% level of significance (p<0.05). Experiments were carried out in triplicates.

3. Results

The scores of sensory analyses of the control and functional ice cream samples for body and texture, color and appearance, flavor, and mouthfeel showed that non-significant (p>0.05) differences were observed for all sensory scores up to 45 days. Comparable results showed no change in liking after storage across treatment levels, and all like scores were lower after storage than the evaluated scores of freshly prepared ice creams. However, only the aged samples were statistically lower in overall liking than the fresh samples (Rolon *et al.,* 2017).

3.1 Change in the sensory attributes over the storage

Sensory evaluation revealed that the ten semi-trained panellists found a significant (p<0.05) difference in color and appearance, body and texture, flavor, and mouthfeel of the ice cream samples after a certain period of storage (Saloni *et al.,* 2019).

3.1.1 Changes in body and texture of functional ice cream during storage of 90 days at 15 days intervals

The sensory score of body and texture of functional and control ice cream were tabulated in Table 1. During storage, it was found that the body and texture scores of control, BRP1, and optimized A2 samples showed no significant (p>0.05) differences up to 45 days of storage (Figure 2). The addition of black rice powder (BRP1) and encapsulated anthocyanins (A2) in ice cream samples produced different bodies and textures in ice cream samples as compared to the control ice cream sample.

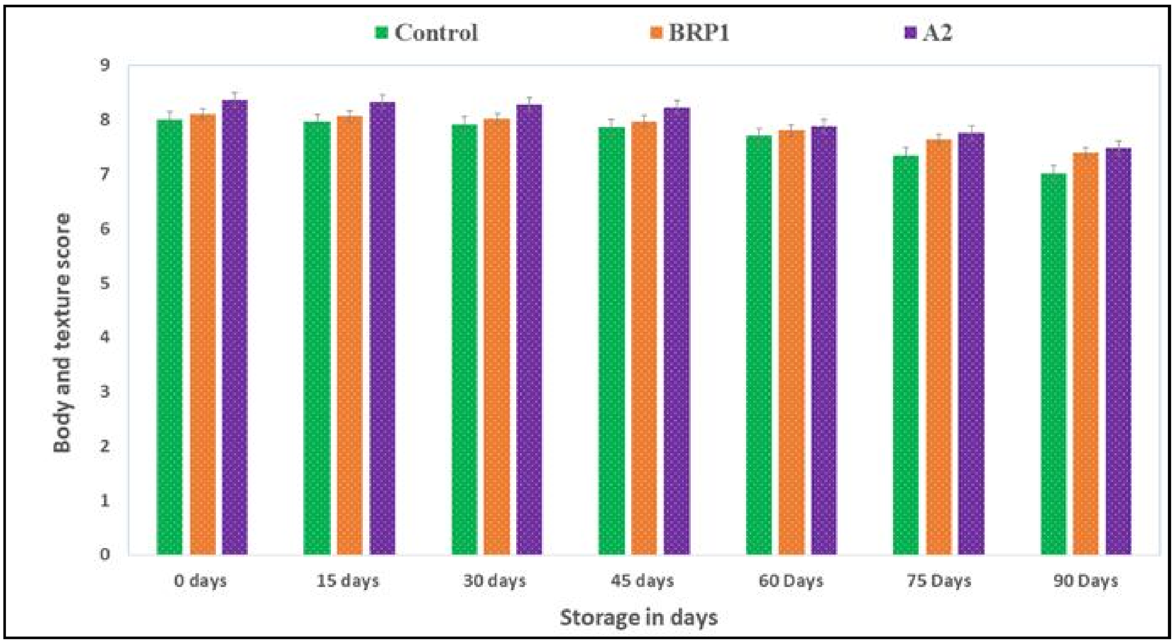

Figure 2: Changes in body and texture score of control, BRP1, and optimized (A2) ice cream over the storage period.

A reduction in the body and texture of ice cream samples was observed over a storage of 90 days. The reduction in body and texture score of control, BRP1, and A2 samples were in the range of 8.01 ± 0.06 to 7.02 ± 0.03, 8.11 ± 0.06 to 7.40 ± 0.45, 8.37 ± 0.06 to 7.49 ± 0.02, respectively.

Table 1: Changes in body and texture score of control, BRP1, and optimized (A2) ice cream over the storage period

Days	Control	BRP1	A2
0	8.01 ± 0.06^{a}	8.11 ± 0.06^{a}	8.37 ± 0.06^{a}
15	7.97 ± 0.01^{a}	8.07 ± 0.02^{a}	8.33 ± 0.01^{a}
30	7.92 ± 0.02^{a}	8.02 ± 0.01^{a}	8.29 ± 0.01^{a}
45	7.87 ± 0.03^{a}	7.98 ± 0.10^{a}	8.24 ± 0.01^{a}
60	7.71 ± 0.03^{b}	7.81 ± 0.02^{b}	7.89 ± 0.01^{b}
75	7.35 ± 0.03^{c}	7.64 ± 0.03^{c}	7.77 ± 0.06^{c}
90	7.02 ± 0.03^{d}	7.40 ± 0.45^{d}	7.49 ± 0.02^{d}

All values are expressed as Mean ± SD (n=3). Different superscripts in the same column indicate significant difference (p<0.05).

3.1.2 Changes in colour and appearance of functional ice cream during storage of 90 days at 15 days intervals.

The sensory score of color and appearance of functional and control ice cream were tabulated in Table 2. During storage, it was found that the color and appearance scores of the control, BRP1, and optimized A2 samples showed no significant ($p>0.05$) differences up to 45 days of storage (Figure 3). Anthocyanins are water-soluble pigments and had purple in color. Anthocyanins are highly sensitive to pH, light, temperature, acidity, and other external environment and are easily degraded (Paiva *et al.,* 2014). The reduction in color and appearance score of control, BRP1, and A2 samples were in the range of 7.86 ± 0.06 to 7.06 ± 0.45, 8.17 ± 0.06 to 7.33 ± 0.02, 8.45 ± 0.02 to 8.02 ± 0.39, respectively.

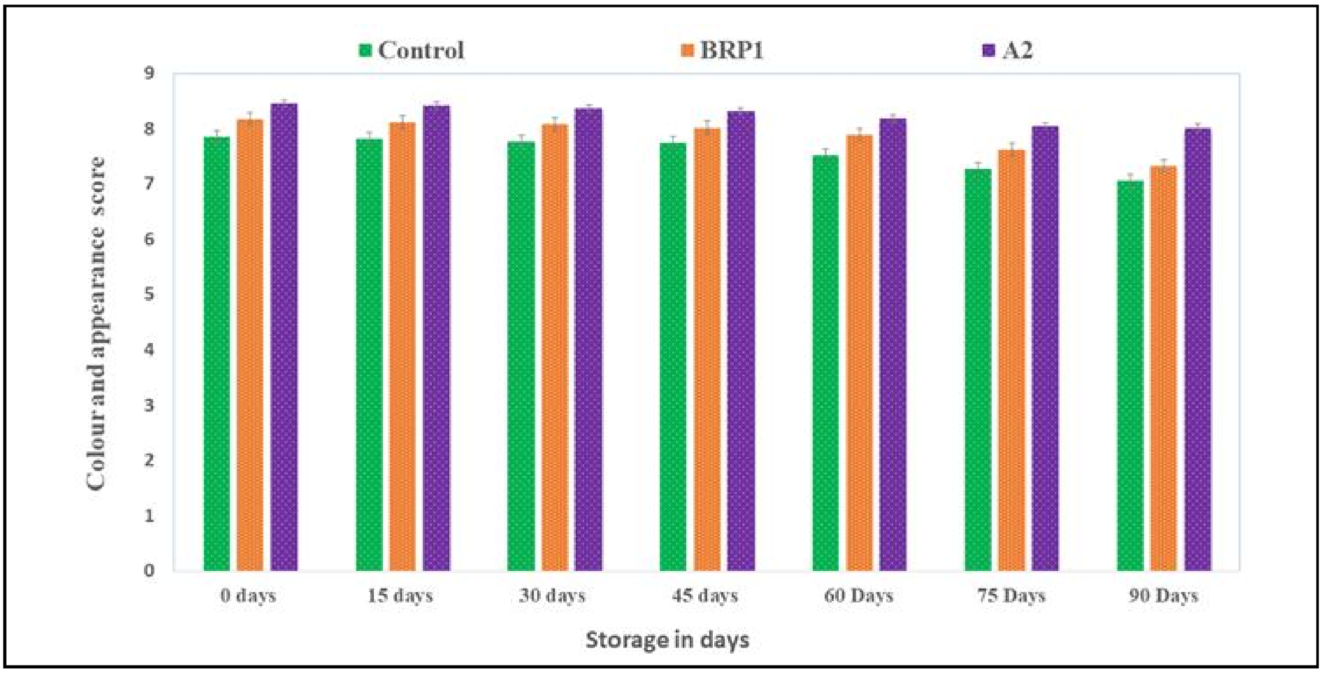

Figure 3: Changes in colour and appearance score of control, BRP1, and optimized (A2) ice cream over the storage period.

So, it was observed that after 45 days of storage, there were significant ($p<0.05$) differences in the color and appearance of ice cream samples due to the degradation of anthocyanin pigment because of change in pH, the acidity of ice cream samples. The changes in color and appearance of control samples were due to the shrinkage that occurred during storage and it might be the reason behind the lowered color and appearance score.

Table 2: Change in colour and appearance score of control, BRP1, and optimized (A2) ice cream over the storage period

Days	Control	BRP1	A2
0	7.86 ± 0.06^{a}	8.17 ± 0.06^{a}	8.45 ± 0.02^{a}
15	7.81 ± 0.05^{a}	8.12 ± 0.04^{a}	8.41 ± 0.06^{a}
30	7.77 ± 0.03^{a}	8.08 ± 0.02^{a}	8.37 ± 0.03^{a}
45	7.74 ± 0.04^{a}	8.02 ± 0.02^{a}	8.31 ± 0.01^{a}
60	7.52 ± 0.04^{b}	7.89 ± 0.02^{b}	8.18 ± 0.01^{b}
75	7.27 ± 0.04^{c}	7.63 ± 0.01^{c}	8.05 ± 0.01^{c}
90	7.06 ± 0.45^{d}	7.33 ± 0.02^{d}	8.02 ± 0.39^{d}

All values are expressed as Mean ± SD (n=3). Different superscripts in the same column indicate significant difference ($p<0.05$).

3.1.3 Changes in flavour of functional ice cream during storage of 90 days at 15 days intervals

The sensory score of flavour of functional and control ice cream were tabulated in Table 3. During storage, it was found that the flavor score of the control, BRP1, and optimized A2 sample showed no significant ($p>0.05$) differences up to 45 days of storage (Figure 4). Black rice powder and anthocyanins had a particular flavor. So, the replacement of SMP with BRP in BRP1 samples and incorporation of encapsulated anthocyanin in optimized (A2) samples showed different flavors as compared to the control sample. Anthocyanins are highly sensitive to pH, light, temperature, acidity, and other external environment and are easily degraded (Paiva *et al.,* 2014). The flavor perception was lowered after 45 days of storage in BRP1 and optimized (A2) samples. The reduction in flavor score of control, BRP1, and A2 samples was in the range of 8.18 ± 0.01 to 7.23 ± 0.03, 8.31 ± 0.01 to 7.29 ± 0.05, 8.69 ± 0.18 to 7.52 ± 0.01, respectively.

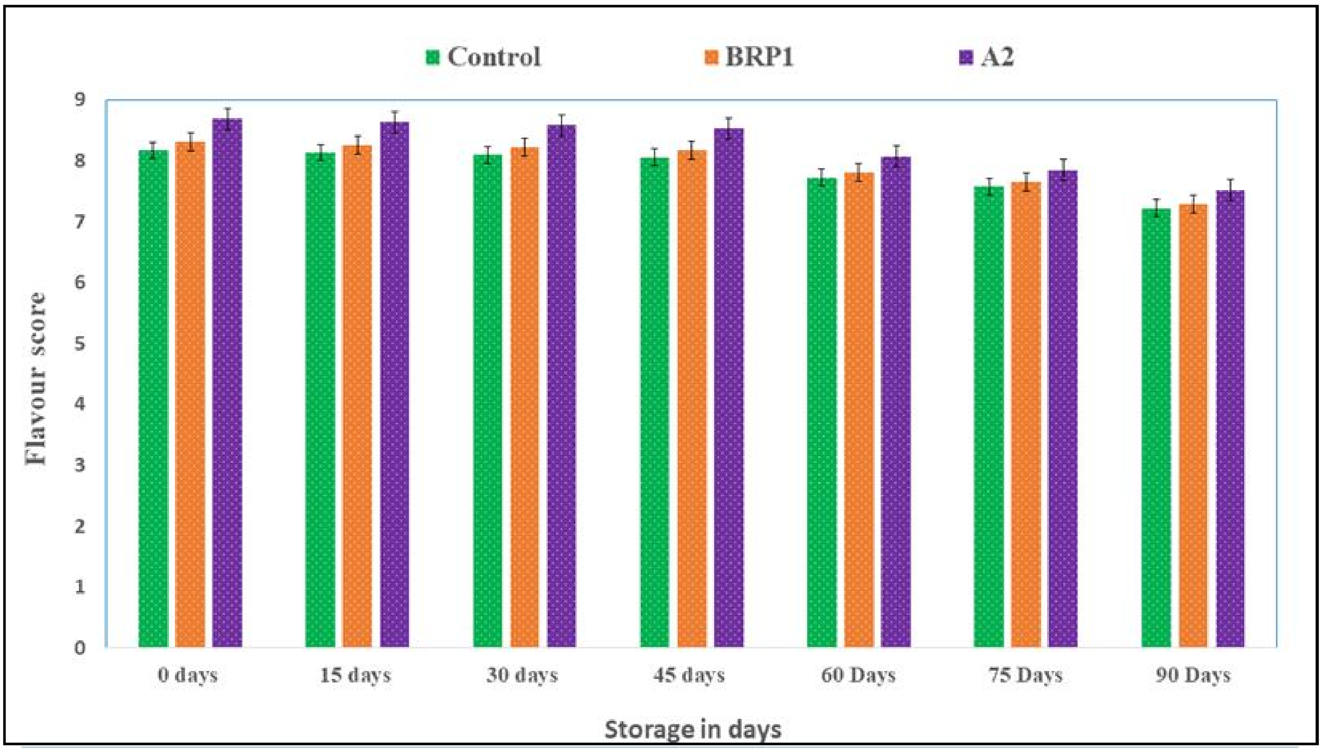

Figure 4: Change in flavour score of control, BRP1, and optimized (A2) ice cream over the storage period.

So, it was observed that after 45 days of storage, there were significant ($p<0.05$) differences in the flavor of ice cream samples due to the degradation of anthocyanin pigment and changes in the complex structure of polysaccharides led to an alteration in the flavor of ice cream samples. The changes in the flavor of control samples were due to the formation of large crystals of ice in the sample that occurred during storage and it might be the reason behind the lowered flavor score.

Table 3: Changes in flavour score of control, BRP1, and optimized (A2) ice cream over the storage period

Days	Control	BRP1	A2
0	8.18 ± 0.01^{a}	8.31 ± 0.01^{a}	8.69 ± 0.18^{a}
15	8.14 ± 0.02^{a}	8.27 ± 0.03^{a}	8.64 ± 0.01^{a}
30	8.10 ± 0.03^{a}	8.23 ± 0.02^{a}	8.59 ± 0.04^{a}
45	8.06 ± 0.02^{a}	8.18 ± 0.01^{a}	8.54 ± 0.01^{a}
60	7.73 ± 0.03^{b}	7.81 ± 0.04^{b}	8.08 ± 0.01^{b}
75	7.58 ± 0.03^{c}	7.65 ± 0.02^{c}	7.85 ± 0.01^{c}
90	7.23 ± 0.03^{d}	7.29 ± 0.05^{d}	7.52 ± 0.01^{d}

All values are expressed as Mean ± SD (n=3). Different superscripts in the same column indicate significant difference ($p<0.05$).

3.1.4 Changes in mouthfeel of functional ice cream during storage of 90 days at 15 days intervals

The sensory score of mouthfeel of functional and control ice cream were tabulated in Table 4. During storage, it was found that the mouthfeel score of the control, BRP1, and optimized A2 sample showed no significant ($p>0.05$) differences up to 45 days of storage (Figure 5). Black rice powder and anthocyanins had a particular taste. So, the replacement of SMP with BRP in BRP1 samples and incorporation of encapsulated anthocyanin in optimized A2 samples showed different tastes as compared to the control sample.

Anthocyanins are highly sensitive to pH, light, temperature, acidity, and other external environment and are easily degraded (Paiva *et al.*, 2014). The mouthfeel score was lowered after 45 days of storage in BRP1 and optimized (A2) samples.

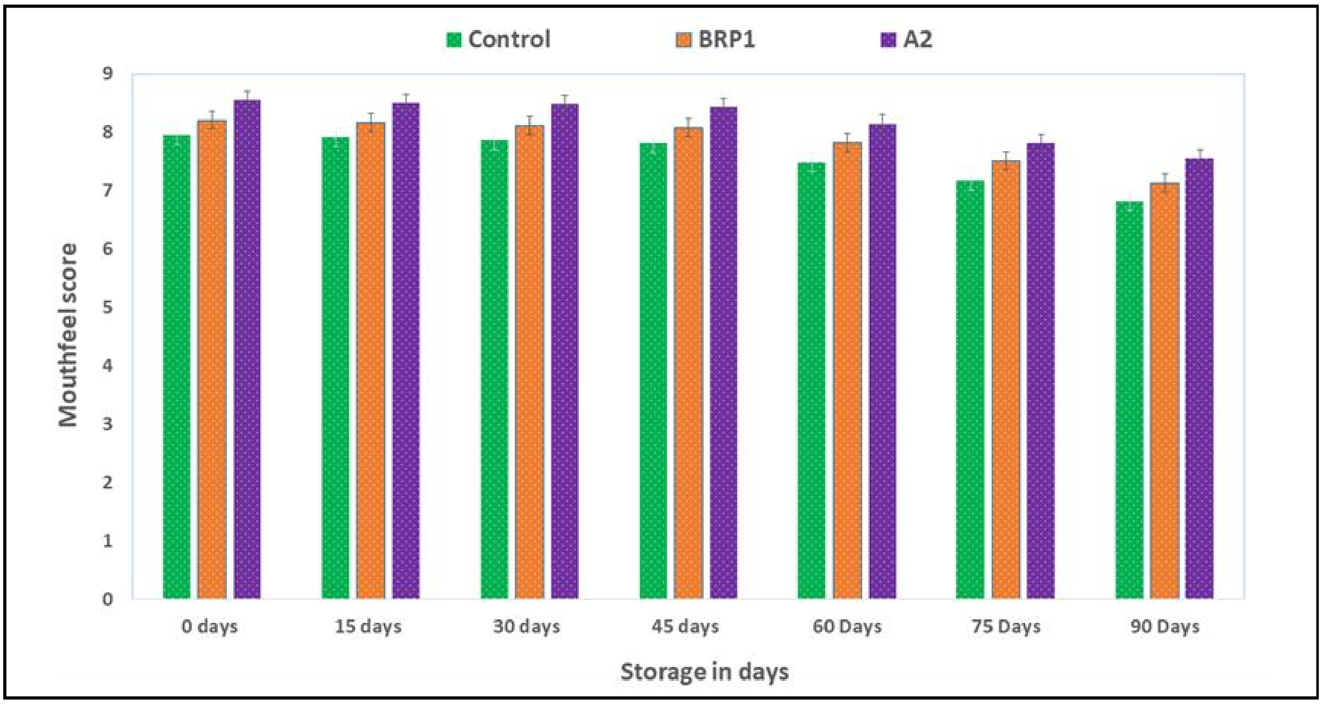

Figure 5: Changes in mouthfeel of functional ice cream during storage of 90 days at 15 days intervals.

So, it was observed that after 45 days of storage, there were significant (p<0.05) differences in the mouthfeel of ice cream samples due to the degradation of anthocyanin pigment and changes in the complex structure of polysaccharides led to an alteration in the mouthfeel of ice cream samples.

Table 4: Changes in mouthfeel of functional ice cream during storage of 90 days at 15 days intervals

Days	Control	BRP1	A2
0	8.25 ± 0.01^a	8.27 ± 0.01^a	8.45 ± 0.06^a
15	8.03 ± 0.04^a	7.99 ± 0.01^a	8.30 ± 0.01^a
30	7.73 ± 0.03^a	7.79 ± 0.01^a	7.98 ± 0.05^a
45	7.43 ± 0.02^a	7.41 ± 0.05^a	7.78 ± 0.02^a
60	6.99 ± 0.03^b	7.12 ± 0.01^b	7.50 ± 0.01^b
75	6.70 ± 0.04^c	6.81 ± 0.01^c	7.31 ± 0.02^c
90	6.33 ± 0.02^d	6.43 ± 0.04^d	7.16 ± 0.04^d

All values are expressed as Mean ± SD (n=3). Different superscripts in the same column indicate significant difference (p<0.05).

The changes in the mouthfeel of control samples were due to the formation of large crystals of ice, and shrinkage in the sample that occurred during storage and it might be the reason behind the lowered flavor score.

4. Discussion

Black rice varieties are a good source of bioactive compounds and have potential antioxidant activity with the anthocyanin content ranging from 19.40 to 140.81 mg cyanidin-3-glucoside/100 g, the total phenolic content ranging from 336.69 to 665.16 mg gallic acid equivalent/100 ml, and the total antioxidant activity ranged between 59.9 and 83.9%, respectively. Reduction in body and texture was analyzed, due to complex frameworks of amylose-lipid, amylose-protein, and significant amounts of amylopectin branches in pigmented black rice powder and encapsulated anthocyanin powder (Pradipta *et al.*, 2020). Comparable results reported that the sensory evaluation scores revealed that an increase in resistant starch (RS) amount in the ice cream led to a decrease in its overall acceptance due to the flour and starchy taste that RS had imparted to the ice cream (Azari-Anpar *et al.*, 2017). The addition of bioactive metabolites to product formulations was primarily intended to facilitate value addition, export promotion, and product diversification (Rai *et al.*, 2020). The sensory panel reported heavy and soggy bodies in the ice cream samples due to the shrinkage in ice cream samples and temperature fluctuation during storage. The shrinkage that occurred during storage might be the reason behind the lowered color and appearance score. A similar finding explained that body and texture, color and appearance, and flavor scores decreased after 5 weeks of storage. The mouthfeel perceptions were lowered after 7 weeks of storage in the control sample and in the case of the optimized sample (Roy *et al.*, 2022).

5. Conclusion

The findings of current study showed that no significant differences were observed for all the sensory scores up to 45 days of storage in both the control and optimized ice cream samples. After 45 days of storage, a decrease in sensory scores was observed. The body and texture, color and appearance, flavor, and mouthfeel score decreased after 45 days of storage in optimized ice cream. The score was significantly ($p<0.05$) reduced after 45 days of storage during the storage period of 90 days.

Acknowledgments

The authors would like to acknowledge the Department of Dairy Science and Food Technology of Institute of Agricultural Sciences and Department of Chemistry, Banaras Hindu University for providing chemicals and instrumental facilities.

Conflict of interest

The authors declare that there are no conflicts of interest in the course of conducting the research. All the authors had a final decision regarding the manuscript and the decision to submit the findings for publication.

References

Azari-Anpar, M.; Khomeiri, M.; Ghafouri-Oskuei, H. and Aghajani, N. (2017). Response surface optimization of low-fat ice cream production by using resistant starch and maltodextrin as a fat-replacing agent. Journal of Food Science and Technology, **54**:1175-1183.

Karthikeyan, N.; Elango, A.; Kumaresan, G.; Gopalakrishnamurty, T. R. and Raghunath, B. V. (2014). Enhancement of probiotic viability in ice cream by microencapsulation. International Journal of Science, Environment, and Technology, **3**(1):339-347.

Paiva, F. F.; Vanier, N. L.; Berrios, J. D. J.; Pan, J.; de Almeida Villanova, F.; Takeoka, G.; Elias, M. C. (2014). Physicochemical and nutritional properties of pigmented rice subjected to different degrees of milling. Journal of Food Composition and Analysis, **35**(1):10–17.

Patel, V.; Rai, D. C.; Singh, U. P. and Rathaur, A. (2022). Development of functional ice cream using niger *(Guizotia abyssinica* (Lf) Cass.) seed oil microcapsules. Ann. Phytomed., **11**(1):588-594.

Pradipta, S.; Ubaidillah, M. and Siswoyo, T. A. (2020). Physicochemical, functional and antioxidant properties of pigmented rice. Current Research in Nutrition and Food Science, **8**(3):837- 851.

Rai, H. K.; Rai, D. C.; Arvind and Saloni. (2020). Process optimization of low calorie and fiber enriched 'sandesh' using response surface methodology (RSM). Ann. Phytomed., **9**(1):229-236.

Rolon, M. L.; Bakke, A. J.; Coupland, J. N.; Hayes, J. E. and Roberts, R. F. (2017). Effect of fat content on the physical properties and consumer acceptability of vanilla ice cream. Journal of Dairy Science, **100**(7):5217-5227.

Roy, S.; Hussain, S. A.; Prasad, W. G. and Khetra, Y. (2022). Quality attributes of high protein ice cream prepared by incorporation of whey protein isolate. Applied Food Research, **2**(1):00029.

Saloni; Meena, S.; Rai, D. C.; Panda, P. and Kumar, S. (2022). A comprehensive review on *Bacopa monnieri* (L.) Pennell (Brahmi): Utilization as a functional food ingredient and health-promoting attributes. Ann. Phytomed., **11**(1), 142-150.

Saloni; Rai, D. C.; Rai, H. K. and Kumar V. (2019). Process optimization for manufacturing of banana enriched ice-cream by using response surface methodology. International Journal of Chemical Studies, **7**(5):1310-1315.

Saloni; Rai, D. C.; Rai, H. K. and Kumar, V. (2020). Physico-chemical analysis of control and optimized banana enriched ice cream during the storage period (60 days) at 15 days intervals. Indian Journal of Dairy Science, **73**(5):402-408.

Sharma, N. and Sarwat, M. (2022). Functional foods for better health and weight loss. Ann. Phytomed., **11**(2):114-121.

Singh, U. P.; Rai, D. C.; Rathaur, A. and Patel, V. (2022). Development of functional shrikhand incorporated with flaxseed (*Linum usitatissimum* L.) oil microcapsules. Ann. Phytomed., **11**(1):745-750.

Citation **Saloni, Dinesh Chandra Rai, Raj Kumar Duary and Subhadip Manik (2023). Efficacy of pigmented rice and its bioactive compounds on the organoleptic assessment of functional ice cream during storage. Ann. Phytomed., 12(1):648-654. http://dx.doi.org/10.54085/ap.2023.12.1.90.**