

Effect of Wheat Bran Fortification on the Quality Attributes of Ice Cream

Buğday Kepeği İlavesinin Dondurmanın Kalite Özellikleri Üzerine Etkisi

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ABSTRACT

The objective of this study was to evaluate the impact of adding 2.5% wheat bran (WB2) and 5% wheat bran (WB5) on the physicochemical, rheological, color, and sensory properties of ice cream. Increases were observed in dry matter ash and acidity values, while decreases were observed in fat and pH values. The results of the physicochemical analysis showed the following values: 36.86-38.62% for dry matter, 0.57-0.61% for ash, 0.16-0.23% for acidity, 6.40-8.30% for fat, and 6.37-6.57 for pH. The WB5 sample showed higher dry matter and ash contents, whereas fat content decreased compared to the control (C). Increasing wheat bran levels were associated with increased acidity and decreased pH. The first dripping time of ice creams containing 5% bran increased, while their melting rate decreased. A substantial increase in apparent viscosity was revealed by rheological analysis with wheat bran addition at both 20 and 50 rpm, especially in WB5. Color measurements revealed that wheat bran significantly reduced the L^* and whiteness index (WI) values, while also increasing the a^* , b^* , chroma (C^*), and hue angle (H°) values. These changes resulted in darker coloration. Sensory evaluation showed a general decline in panel scores with higher wheat bran levels. Although the control had high scores, the scores of the ice creams with added wheat bran were also acceptable. Wheat bran, commonly utilized as animal feed, was chosen to investigate its potential application as a functional food in human diets.

Keywords: Ice cream, wheat bran, viscosity, sensory properties, color parameters

Öz

Bu çalışma ile, dondurmaya %2,5 buğday kepeği (WB2) ve %5 buğday kepeği (WB5) ilave edilmesinin fizikokimyasal, reolojik, renk ve duyu özellikleri üzerindeki etkisi araştırılmıştır. Kepek ilavesi ile dondurmaların kuru madde, kül ve asitlik değerlerinde artışlar, yağ ve pH değerlerinde ise azalmalar gözlenmiştir. Fizikokimyasal analiz sonuçlarına göre kuru madde %36,86-38,62, kül %0,57-0,61, asitlik %0,16-0,23, yağ %6,40-8,30 ve pH 6,37-6,57 aralıklarında ölçülmüştür. WB5 örneği daha yüksek kuru madde ve kül içeriği gösterirken, yağ içeriğinin kontrole (C) kıyasla azaldığı tespit edilmiştir. Buğday kepeği oranının artması ile asitliğin arttığı ve pH değerinin düştüğü gözlenmiştir. %5 kepek içeren dondurmanın ilk damlama süresi artarken, erime hızının azaldığı tespit edilmiştir. Reolojik analizde, hem 20 hem de 50 rpm'de özellikle WB5'te, belirgin viskozitenin artışı ortaya çıkmıştır. Renk ölçümleri, buğday kepeğinin L^* ve beyazlık indeksi (WI) değerlerini önemli ölçüde düşürdüğünü, aynı zamanda a^* , b^* , kroma (C^*) ve renk tonu açısı (H°) değerlerini de artırdığını göstermiştir. Bu değişiklikler kepek ilave edilen dondurmalarda daha koyu renklerin ortaya çıkmasına sebep olmuştur. Duyusal değerlendirmede, daha yüksek buğday kepeği seviyeleri panelist puanlamalarında genel bir düşüşe sebep olduğu belirlenmiştir. Kontrol yüksek puanlar almış olsa da buğday kepeği ilaveli dondurmaların puanları da kabul edilebilir düzeyde bulunmuştur. Hayvan yemi olarak kullanılan kepeğin insan beslenmesinde fonksiyonel gıda olarak değerlendirilmesi amacıyla buğday kepeği seçilmiştir.

Anahtar Kelimeler: Dondurma, buğday kepeği, viskozite, duyu test, renk değerleri

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Introduction

Wheat has a 10,000-year history, and agricultural evolution reflects its nutritional importance. Today, wheat-based diets are increasing due to urbanization and industrialization, further amplifying global reliance on (Saini et al., 2023). Wheat (*Triticum* spp.), a globally significant cereal crop, belongs to the *Triticeae* tribe within the *Poaceae* family (Cheng et al., 2022). Derived from the outer layers of wheat grains, wheat bran (WB) is the major by-product of milling, constituting 15–20% of the grain's weight (Cheng et al., 2022; Onipe et al., 2015; Saini et al., 2023). Its availability positions it as a sustainable material (Cheng et al., 2022). It provides a complete profile of 18 amino acids, encompassing all essential varieties (Cheng et al., 2022). Additionally, WB is rich in nutritional elements such as minerals (Fe, Zn, Mg, P), vitamins (B₁, B₆, folate (B₉), and E), phytochemical components, and antioxidants (phenolic compounds) (Onipe et al., 2015; Stevenson et al., 2012).

Cereals serve as the primary source of dietary fiber for humans, contributing approximately 50% of total intake. Vegetables provide 30–40%, fruits supply 16%, and nuts account for the remaining 3% of dietary fiber requirements. The wheat is the richest among cereals, especially WB in wheat, in terms of dietary fibre (Sztupecki et al., 2023). WB contains high amount dietary fibre (about 50%) (Onipe et al., 2015; Sztupecki et al., 2023). The primary components of WB were 32.1 cellulose, 29.2% hemicellulose, 16.4% lignin, and 22.3% extracts (Cheng et al., 2022).

Dietary consists of polysaccharides, and bioactive compounds which having beneficial effects on human health (Wang et al., 2024). Wheat bran-derived dietary fiber exhibits significant physiological benefits, particularly in mitigating risks associated with metabolic and cardiovascular disorders, including coronary heart disease, obesity, glucose intolerance, T2DM, and specific cancer types (Budhwar et al., 2020; Wang et al., 2024).

With increasing awareness of health and nutrition, researchers and consumers are showing greater interest in natural food sources, non-toxic bioactive food components capable of mitigating oxidative stress and chronic disease progression (Onipe et al., 2015; Wang et al., 2024). WB has usually been used as an animal feed unit for a long time (Chen et al., 2024), whereas its consumption and use by humans have shown an increase in recent years (Onipe et al., 2015). The research number has increased regarding the use of WB in foods day to day (Shehata et al., 2022; Terpou et al., 2017).

The ice cream contains many nutritional elements such

as protein, fat, carbohydrate, vitamins, and minerals (Goff et al., 1999). The ice cream is high nutritional value and caloric, whereas it is poor in terms of dietary fibre. The number of research studies have increased to invent a new product due to the desires of consumers for healthy, natural, and functional ice cream. The different forms of fruits, vegetables, and byproducts are used in ice cream formulations for this goal (Soukoulis et al., 2014; Ürkek, 2025; Ürkek et al., 2022b). The nutritional and functional properties of ice cream added with herbal content improve, in addition to some quality properties (Sayar et al., 2022; Ürkek, 2021).

In this research, WB was added to ice cream in different concentrations (2.5 and 5%), and the effects on the physicochemical, rheological, color and sensory properties of ice cream were investigated.

Material and Methods

Material

The UHT milk, skim-milk powder, sugar, and butter were obtained by local markets. The stabilizer and emulsifier were provided by the patisserie. The WB was obtained from a local flour plant. The WB was ground using a laboratory mill, and it was sifted out with a sieve (125 µm).

Ice cream production

The mix receipt of ice cream was arranged as 75% UHT milk, 16% sugar, 5% butter, 3.3% skim milk powder, 0.5% stabilizer (salep), and 0.2% emulsifier (mono-di gliserid). The ingredients were added to milk, successively butter, salep+sugar, skimmed milk powder+sugar, and emulsifier. Then, the mix was divided into equal parts (three). WB was added to mix different ratios before (2.5 and 5%) pasteurization at 85 °C for 1 min for the samples containing WB. The control sample was produced without WB and was coded as C. The codes of the other samples were WB2, containing 2.5% WB, and WB5, containing 5% WB. After pasteurization, the mixture was chilled to room temperature, and they were kept in a refrigerator (+4 °C) for one night. The ice samples were produced using the Breville BCI600 machine (Sage BSS., Australia). The samples were held in a deep freezer (-22°C), and then stored at -18 °C. The dry matter, ash, fat, protein, lactose, pH, and titratable acidity values were 11.94%, 0.54%, 3.1%, 3.0%, 4.7%, 6.72, and 0.16%, respectively. Some properties of WB were dry matter 92.43%, ash 3.60%, pH 5.87, and 1.41%, and water holding capacity 292.50%.

Methods

Physicochemical analysis

The gravimetric method was used to determine dry matter (%) and ash (%) content. The fat rate was obtained using Gerber method (AOAC, 2005). The pH values were measured with a WTW-3110 pH meter (Weilheim, Germany), while titratable acidity was titration methods using 0.1 N NaOH (Metin, 2009). The overrun calculation was performed following equal (Akbari et al., 2016):

$$\text{Overrun (\%)} = \frac{(\text{weight of mix}) - (\text{weight of ice cream})}{\text{weight of ice cream}} \times 100 \quad (1)$$

The first dripping time of the ice creams was determined using the method reported by (Güven & Karaca, 2002). To evaluate the melting rate, the amount of melted ice cream was weighed at 10-minute intervals up to 90 minutes, and the results were analyzed using a regression curve (Öztürk-Yalçın et al., 2024).

Viscosity and rheological analysis

The viscosity of the ice cream samples was analyzed using a Brookfield Viscometer (Model DV-II, Brookfield Engineering Laboratories, Stoughton, MA, USA) with spindle no. 5. Measurements were taken at +4°C with a 30-second reading time, and the results were recorded in centipoise (cP). To determine the rheological properties of the samples, viscosity values were measured at shear rates ranging from 5 to 100 rpm, and the data were calculated with the power-law model. In this model, η represents apparent viscosity (Pa.s), K is the consistency coefficient (Pa.sⁿ), $\dot{\gamma}$ denotes shear rate (1/s), and n is the flow behavior index (Steffe J.F. 1967). The equation is in order:

$$\eta = K\dot{\gamma}^{(n-1)} \quad (2)$$

Colorimetric parameters

The color parameters of the ice cream samples were determined using a chroma meter (CR-200, Minolta Camera Co., Osaka, Japan). The instrument, calibrated with a standard white porcelain tile, measured the samples' brightness (L^* : 0=black, 100=white), redness/greenness (a^* : +/- values), and yellowness/blueness (b^* : +/- values). Hue angle (H°) was calculated according to the method described by (McLellan et al., 1995), while chroma (C^*) representing color saturation were determined using the method specified by (Cecchini et al., 2011). The whiteness index (WI) was calculated following the method employed by (Kurt & Atalar, 2018).

$$WI = 100 - \sqrt{(100 - L^*)^2 + (a^*)^2 + (b^*)^2} \quad (3)$$

Sensory test

The sensory evaluation of the samples was conducted by a semi-trained panel of 48 volunteers (20 female, 28 male, aged 25–45). Ice cream samples were assessed based on a 9-point hedonic scale (1: disliked extremely, 9: liked extremely) for color, gumming structure, icy structure, smooth structure, flavor, foreign flavor, meltdown in mouth, resistance to melting, and overall acceptability (Meilgaard et al., 1999).

Statistical analysis

The data obtained in the study were analyzed using the SPSS 21 statistical package (IBM SPSS Corp., Armonk, NY, USA). The effects of variances were evaluated by one-way Analysis of Variance (ANOVA), and differences between means were determined using Duncan's multiple range test at $p < .05$ significance level.

Results and Discussion

Physicochemical properties

The results of the physicochemical analysis of the ice creams are shown in Table 1. The dry matter content of the ice cream samples ranged from 36.08% to 38.62%. There was no significant difference between the control (37.08%) and the WB2 (36.86%) samples, whereas WB5 (38.62%) showed a statistically significant increase ($p < .05$). Qayyum et al. (2017) observed an increase in dry matter content following the inclusion of watermelon seed. Similarly, Dervisoglu (2006) reported a progressive rise in dry matter content with increasing levels of hazelnut flour. Taken together, these results are largely consistent with those obtained in the present study. The increase in dry matter content observed in bran-enriched samples can be attributed to the inherently high dry matter composition of wheat bran.

The ash content of the ice cream samples ranged from 0.57% to 0.71%. The C sample had the lowest ash content (0.57%), while the WB5 sample had the highest (0.71%). The inclusion of wheat bran had a statistically significant effect on ash content ($p < .05$). Higher bran concentrations corresponded to higher ash levels. Similar findings have been reported in the literature. Ürkek et al. (2021) found that adding ground chia seeds to ice cream formulations increased ash content. Similarly, Gürpınar et al. (2022) observed comparable increases in ash levels with higher

concentrations of apple, orange, and pumpkin fibers. These studies suggest that higher concentrations of plant-based additives tend to increase ash content in ice cream formulations.

Table 1.
Physicochemical properties of ice cream samples containing wheat bran

	C	WB2	WB5
Dry matter (%)	37.08 ± 0.15 ^A	36.86 ± 0.23 ^A	38.62 ± 0.11 ^B
Ash (%)	0.57 ± 0.01 ^A	0.60 ± 0.01 ^B	0.71 ± 0.01 ^C
Fat (%)	8.30 ± 0.14 ^B	7.00 ± 0.28 ^A	6.40 ± 0.57 ^A
Acidity (% lactic acid)	0.16 ± 0.02 ^A	0.20 ± 0.02 ^B	0.23 ± 0.01 ^B
pH	6.57 ± 0.01 ^C	6.46 ± 0.00 ^B	6.37 ± 0.01 ^A
First dripping time (s)	1950.00 ± 127.28 ^A	2070.00 ± 143.14 ^{AB}	2340.00 ± 84.85 ^B
Melting rate (g/min)	0.93 ± 0.02 ^B	0.90 ± 0.03 ^{AB}	0.84 ± 0.00 ^A
Overrun (%)	50.55 ± 2.90 ^A	50.55 ± 0.88 ^A	42.81 ± 3.88 ^A

^{A-C}: Means denoted by different letters are statistically different from each other at the $p < 0.05$ significance level. Values are expressed as mean ± standard deviation (n=3). Different superscript letters within the same row indicate significant differences among means ($p < .05$), according to Duncan’s test. C: Control ice cream (without wheat bran); WB2: Ice cream with 2.5% wheat bran; WB5: Ice cream with 5% wheat bran.

Acidity ranged from 0.16% to 0.23%, while pH values varied between 6.57 and 6.37. When acidity and pH values are considered together, it can be observed that the C sample, which had the lowest acidity (0.16%), showed the highest pH value (6.57). Conversely, the WB5 sample, which had the highest acidity (0.23%), exhibited the lowest pH value (6.37). Trivedi et al. (2014) added basil as a flavoring agent in their ice cream formulation, while Gabbi et al. (2018) incorporated both ginger juice and ginger powder into ice cream compositions. In both studies, a slight increase in acidity and a corresponding decrease in pH were observed compared to the control group. The differences observed in acidity and pH in the present study are attributed to the addition of wheat bran.

The fat content of the ice cream samples varied across formulations. The C sample exhibited the highest fat content (8.30%), whereas the lowest fat content was recorded in the WB5 sample (6.40%). A similar reduction in fat content has been observed in several previous studies incorporating plant-based ingredients. For instance, Aloğlu et al. (2018) added strawberry tree fruit

(*Arbutus unedo* L.) to ice cream and found that fat content decreased proportionally with increasing fruit concentration. Aliyev (2006) reported comparable findings in kefir-based ice creams enriched with blueberry, noting a decline in fat content with higher fruit concentrations. Overall, the current study indicates that increasing wheat bran concentration decreases fat content.

The values of the first dripping times of the ice cream samples ranged from 1950 to 2340 s, indicating statistically significant differences ($p < .05$) among the samples. Melting rates varied from 0.93 g/min to 0.84 g/min (Table 1). Ürkek et al. (2022b) reported first dripping times ranging from 1440 to 2190 seconds and melting rates from 1.32 to 1.90 g/min for ice creams produced with different plant powders Aloğlu et al. (2018) found that increasing the concentration of strawberry tree fruit purée in ice cream resulted in a softer texture, longer first dripping times, and lower melting rates. According to Doğancı et al. (2024), raising the concentration of avocado purée improves the melting resistance of ice cream. Similarly, Moolwong et al. (2023) demonstrated that the water-binding capacity of dietary fibers reduces the melting rates of frozen desserts. In line with these findings, the current study showed that increasing wheat bran concentration extended the first dripping time and reduced the melting rate. This behavior is likely due to the presence of natural fibers in wheat bran, which may slow down melting by enhancing water retention within the ice cream matrix.

The overrun values of the ice cream samples ranged from 50.55% to 42.81%. Although the inclusion of wheat bran resulted in a reduction in overrun, this difference was not statistically significant. Several studies support the observation that plant-based additives may limit air incorporation in ice cream. For instance, Mesut Çınar & Çelik (2022) found that the addition of lemon balm extract reduced overrun compared to the control. Similarly, Trivedi et al. (2014) reported that, although basil juice did not have a statistically significant impact, it still led to a noticeable reduction. Qayyum et al. (2017) recorded overrun values ranging between 27.43% and 43.93% in ice creams enriched with watermelon seed powder, concluding that this ingredient negatively affected air incorporation. Ürkek et al. (2022b) found that plant

powder-enriched samples had lower overrun than powder-free samples, though the differences were not statistically significant. Overall, these findings suggest that the decrease in overrun observed in the current study may be due to the bran's interference with air entrapment during freezing, likely related to its fiber structure and water absorption capacity.

Rheological properties

Rheological properties of wheat bran-enriched ice cream samples are presented in Table 2. Apparent viscosity values increased significantly ($p < .05$) with the addition of wheat bran at both 20 rpm and 50 rpm. At 20 rpm, the control sample (C) exhibited a viscosity of 5386.52 cP, while samples containing 2.5% (WB2) and 5% (WB5) wheat bran showed higher viscosities of 7077.52 cP and 11599.80 cP, respectively. A similar trend was observed at 50 rpm. Viscosities increased from 2907.94 cP (C) to 3742.12 cP (WB2) and 6214.79 cP (WB5). All these differences were statistically significant ($p < .05$).

Table 2.

Rheological properties of wheat bran-enriched ice cream samples

Viscosity (cP)	C	WB2	WB5
20 rpm	5386.52 ± 217.05 ^A	7077.52 ± 225.59 ^B	11599.80 ± 174.90 ^C
50 rpm	2907.94 ± 18.12 ^A	3742.12 ± 82.19 ^B	6214.79 ± 194.91 ^C
K (Pa.s ⁿ)	39.39 ± 4.44 ^A	52.93 ± 4.71 ^A	79.73 ± 0.67 ^B
n	0.336 ± 0.027 ^A	0.320 ± 0.018 ^A	0.344 ± 0.003 ^A
R ²	0.9999	0.9991	0.9974

Results are presented as means ± standard deviations. Different letters (A, B, C, and D) within the same row indicate statistically significant differences between the means ($p < .05$). C: Ice cream without wheat bran (WB); WB2: Ice cream containing 2.5% WB; WB5: Ice cream containing 5% WB.

The addition of wheat bran significantly influenced the rheological behavior of the ice cream samples, as evidenced by increased viscosity values. The observed increase in apparent viscosity at both shear rates (20 and 50 rpm) with increasing wheat bran concentration may be due to wheat bran's high fiber content, as well as its water-binding and retention capacity. Therefore, wheat bran may cause low serum separation of ice creams. These properties contribute to a denser matrix that restricts flow and increases shear resistance. Similar rheological findings reported by Soukoulis et al. (2009), who observed significant improvement in viscosity and flow consistency

in ice cream formulations enriched with dietary fibers, including wheat, oat, apple, and inulin. Similarly, in another study, the addition of wheat germ caused positive improvements in the viscosity of the ice cream (Salem et al., 2016).

Regarding flow behavior, the consistency index (K) values increased significantly with wheat bran addition, from 39.39 Pa.sⁿ in the control to 79.73 Pa.sⁿ in WB5 ($p < .05$). An increase in the K value with wheat bran addition indicates that bran improves both the initial flow resistance and the structural strength of the ice cream matrix. This enhancement in structure may translate into a perception of increased creaminess or a fuller mouthfeel.

However, the flow behavior index (n) did not differ significantly among samples ($p > .05$), indicating consistent pseudoplastic behavior regardless of bran content, which aligns with the findings of Ürkek et al. (2022a).

Although significant changes were observed in viscosity and consistency, the n value remained statistically unchanged across all formulations. These findings indicate that the samples maintained the pseudoplastic (shear-thinning) flow behavior typical of conventional ice cream systems and that wheat bran increased the ice cream density without fundamentally altering its flow mechanism.

Color parameters

In color measurement, a^* is positive for redness and negative for greenness, while b^* is positive for yellowness and negative for blueness. The L^* value corresponds to brightness, ranging from black (low values) to white (high values). The C^* value (chroma) reflects color intensity, and the WI quantifies whiteness. The hue angle (H°) characterizes the basic shade of color. 0° or 360° corresponds to red; 90° corresponds to yellow; 180° corresponds to green; and 270° corresponds to blue (Ürkek et al., 2022a). The color parameters of ice cream samples enriched with wheat bran are presented in Table 3. The following color parameters were obtained for wheat bran: $L^* = 75.25 \pm 0.15$, $a^* = 3.10 \pm 0.12$, $b^* = 15.22 \pm 0.05$, $C^* = 15.53 \pm 0.03$, and $H^\circ = 78.49 \pm 0.45$.

Table 3.
Color parameters of ice cream samples enriched with wheat bran

	C	WB2	WB5
<i>L*</i>	81.31 ± 0.04 ^C	72.60 ± 0.15 ^B	69.15 ± 0.52 ^A
<i>a*</i>	-3.60 ± 0.11 ^A	0.93 ± 0.08 ^B	2.47 ± 0.31 ^C
<i>b*</i>	6.55 ± 0.04 ^A	11.68 ± 0.11 ^B	14.08 ± 0.64 ^C
<i>C*</i>	7.47 ± 0.07 ^A	11.72 ± 0.10 ^B	14.30 ± 0.68 ^C
<i>H°</i>	118.81 ± 0.64 ^C	85.44 ± 0.37 ^B	80.11 ± 0.80 ^A
<i>WI</i>	79.87 ± 0.06 ^C	70.20 ± 0.14 ^B	65.99 ± 0.74 ^A

Results are presented as means ± standard deviations. Different letters (A, B, C, and D) within the same row indicate statistically significant differences between the means ($p<.05$). C: Ice cream without wheat bran (WB); WB2: Ice cream containing 2.5% WB; WB5: Ice cream containing 5% WB.

The *L** value decreased significantly with increasing wheat bran content ($p<.05$). Sample C exhibited the highest lightness value (81.31) and WB5 exhibited the lowest value (69.15), suggesting that the incorporation of wheat bran darkened the ice cream. Similar findings were reported by Manikanta et al. (2023), who observed that increasing levels of wheat bran in ice cream cone formulations resulted in a noticeable darkening of the product, as evidenced by decreased *L** values and reduced brightness. The results clearly show that adding wheat bran significantly affected the color of the ice cream samples. The decrease in *L** values with increasing wheat bran levels suggests that the product darkened noticeably, which can be attributed to the natural brown pigments and fiber content of wheat bran.

The control sample had a negative *a** value of -3.60, indicating a greenish hue. The values became progressively more positive with increasing bran content, reaching a value of 2.47 in WB5. This points to an increase in redness. A comparable shift toward red hues was reported by Akalin et al. (2018), who observed that the inclusion of plant-based apple, orange, and wheat fibers in probiotic ice cream significantly decreased *L** values and enhanced red (*a**) and yellow (*b**) coloration in the treated samples compared to the control.

The highest *b** value was observed in sample WB2 (15.22), while the control had the lowest yellow intensity (6.55). This is likely due to bran-associated pigments, such as flavonoids and phenolic compounds, which are known to contribute to yellowish-brown tones in cereal-based ingredients (Van Hung, 2016).

A similar pattern was observed in chroma (*C**) values, which indicate color saturation. The highest *C** value was recorded in WB2 (15.53), followed by a gradual decline

with increasing levels of wheat bran. The initial increase in chroma (*C**) at low bran concentrations (WB2) may indicate increased color intensity. The slight decline at higher concentrations (WB5), however, could be due to the dilution or masking of chromaticity caused by more insoluble bran particles (Du et al., 2023).

The *H°* value decreased with the addition of wheat bran, dropping from 118.81° in the control sample to 80.11° in the WB5 sample, suggesting a visible shift in color tone due to bran enrichment.

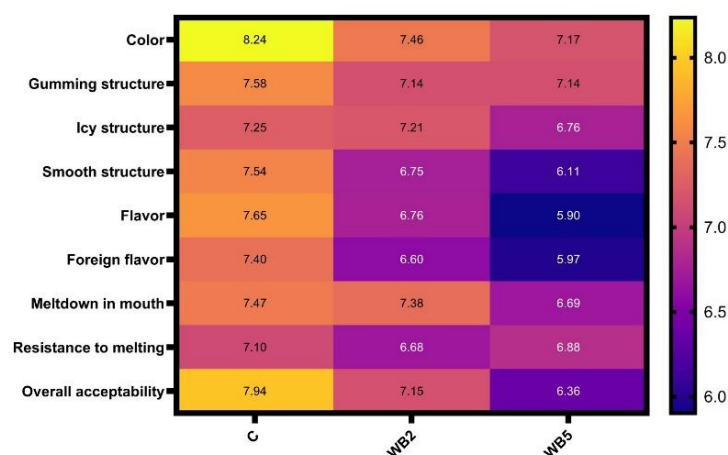
The *WI* value was highest in the C sample (79.87) and decreased significantly with the addition of wheat bran, reaching its lowest value in WB5 (65.99) ($p<.05$). This decrease confirms the darkening effect of wheat bran on ice cream color.

Sensory properties

The sensory characteristics of ice cream samples were evaluated by panelists in terms of color, gumming structure, icy structure, smooth structure, flavor, foreign flavor, meltdown in mouth, resistance to melting, and overall acceptability. The sensory evaluations of ice cream samples produced with wheat bran are presented in Figure 1. The color, icy structure, smooth structure, flavor, foreign flavor, and meltdown scores were the highest control samples, and other samples were designated WB2 and WB5. The control sample was the most highly regarded by the panelists (7.94), while the overall acceptability score of samples WB2 (7.15) was higher than that of sample WB5 (6.36). All samples had higher scores than mean score. Ayar et al. (2018) reported the sensory evaluation of ice cream samples enriched with dietary fibers. Their results indicated that the control sample received the highest sensory scores compared to formulations containing grape, apricot, and sunflower fibers. In contrast to our findings, cereal fiber-enriched ice creams (e.g., those made from corn or rice hulls) demonstrated similar or slightly higher overall acceptability scores compared to the control.

Figure 1.

Effect of wheat bran addition on the sensory properties of ice cream



Conclusion and Recommendations

The inclusion of WB significantly altered the composition and quality characteristics of the samples. From a physicochemical standpoint, adding WB significantly increased dry matter, ash content, acidity, and first dripping time, while decreasing fat content and pH values. These changes suggest that WB can enhance the nutritional value of ice cream, though it may affect product stability and sensory attributes. Notably, the melting rate decreased significantly with higher WB levels, indicating improved thermal resistance.

Fortifying ice cream with wheat bran may provide several nutritional and functional benefits. Wheat bran fortification in ice cream offers a promising approach to enhance its dietary fiber content. It can improve stability and texture while maintaining typical rheological properties. However, excessive bran levels may negatively impact consumer acceptance, highlighting the importance of optimizing the amount incorporated into the formulation.

Wheat bran enrichment significantly altered the visual attributes of ice cream, primarily by reducing its lightness and shifting its color toward warmer, darker tones. These changes are typical of fiber-enriched dairy products and may appeal to health-conscious consumers seeking natural or functional food options.

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References

- Akalın, A. S., Kesenkas, H., Dinkci, N., Unal, G., Ozer, E. & Kınık, O. (2018). Enrichment of probiotic ice cream with different dietary fibers: Structural characteristics and culture viability. *Journal of Dairy Science*, 101(1), 37–46. <https://doi.org/10.3168/JDS.2017-13468>
- Akbari, M., Eskandari, M. H., Niakosari, M. & Bedeltavana, A. (2016). The effect of inulin on the physicochemical properties and sensory attributes of low-fat ice cream. *International Dairy Journal*, 57, 52–55. <https://doi.org/10.1016/j.idairyj.2016.02.040>
- Aliyev, C. (2006). *Kefir ve yaban mersininin dondurmanın fizikokimyasal, duysusal ve mikrobiyolojik özelliklerine etkisi* (Tez No: 185576). [Yüksek Lisans Tezi, Ondokuz Mayıs Üniversitesi Fen Bilimleri Enstitüsü]. YÖK Tez Merkezi.
- Aloğlu, H. Ş., Gökgöz, Y. & Bayraktar, M. (2018). Kocayemiş (Dağ çileği-Arbutus unedo L.) meyveli dondurma üretimi, fiziksel, kimyasal ve duysusal parametreler açısından irdelenmesi. *Gıda*, 43(6), 1030–1039. <https://doi.org/10.15237/GIDA.GD18098>
- AOAC. (2005). *Official Methods of Analysis of the AOAC* (18th ed.).
- Ayar, A., Sıçramaz, H., Öztürk, S., & Öztürk Yılmaz, S. (2018). Probiotic properties of ice creams produced with dietary fibres from by-products of the food industry. *International Journal of Dairy Technology*, 71(1), 174–182. <https://doi.org/10.1111/1471-0307.12387>
- Budhwar, S., Chakraborty, M., Sethi, K. & Chatterjee, A. (2020). Antidiabetic properties of rice and wheat bran—A review. *Journal of Food Biochemistry*, 44(10), 1–10. <https://doi.org/10.1111/jfbc.13424>
- Cecchini, M., Contini, M., Massantini, R., Monarca, D. & Moschetti, R. (2011). Effects of controlled atmospheres and low temperature on storability of chestnuts manually and mechanically harvested. *Postharvest Biology and Technology*, 61(2–3), 131–136.

- <https://doi.org/10.1016/j.postharvbio.2011.03.001>
Chen, Z., Mense, A. L., Brewer, L. R. & Shi, Y. C. (2024). Wheat bran layers: composition, structure, fractionation, and potential uses in foods. *Critical Reviews in Food Science and Nutrition*, 64(19), 6636–6659. <https://doi.org/10.1080/10408398.2023.2171962>
- Cheng, W., Sun, Y., Fan, M., Li, Y., Wang, L. & Qian, H. (2022). Wheat bran, as the resource of dietary fiber: a review. *Critical Reviews in Food Science and Nutrition*, 62(26), 7269–7281. <https://doi.org/10.1080/10408398.2021.1913399>
- Çınar, M. & Çelik, Ş. (2022). Melissa officinalis L. Ekstraktının Dondurma Üretiminde Kullanımı Üzerine Bir Araştırma. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi*, 25(2), 367–373. <https://doi.org/10.18016/KSUTARIMDOGA.VI.846040>
- Dervisoğlu, M. (2006). Influence of hazelnut flour and skin addition on the physical, chemical and sensory properties of vanilla ice cream. *International Journal of Food Science & Technology*, 41(6), 657–661. <https://doi.org/10.1111/J.1365-2621.2005.01127.X>
- Doğancı, H. N., Kırmızı, N. A., Köksal, A. & Kanca, N. (2024). Avokado (Persea americana Mill.) Püresi İlavesiyle Üretilen Yağ İçeriği Azaltılmış Dondurmaların Bazı Fizikokimyasal, Reolojik ve Duyusal Özelliklerinin Belirlenmesi. *Turkish Journal of Agricultural and Natural Sciences*, 11(4), 860–869. <https://doi.org/10.30910/TURKJANS.1471950>
- Du, J., Li, Q., Obadi, M., Qi, Y., Liu, S., an, D., Zhou, X., Zhang, D. & Xu, B. (2023). Quality Evaluation Systems and Methods of the Whole Making Process of Asian Noodles: A Review. *Food Reviews International*, 39(7), 3830–3857. <https://doi.org/10.1080/8755912-9.2021.2013871;SUBPAGE:STRING:FULL>
- Gabbi, D. K., Bajwa, U. & Goraya, R. K. (2018). Physicochemical, melting and sensory properties of ice cream incorporating processed ginger (Zingiber officinale). *International Journal of Dairy Technology*, 71(1), 190–197. <https://doi.org/10.1111/1471-0307.12430;JOURNAL:JOURNAL:14710307;PAGE:STRING:ARTICLE/CHAPTER>
- Goff, H. D., Verespej, E. & Smith, A. K. (1999). A study of fat and air structures in ice cream. *International Dairy Journal*, 9(11), 817–829. [https://doi.org/10.1016/S0958-6946\(99\)00149-1](https://doi.org/10.1016/S0958-6946(99)00149-1)
- Gürpınar, S., Dağdemir, E. & Topdaş, E. F. (2022). Fonksiyonel dondurma: Elma, bal kabağı ve portakal lifi ile zenginleştirme. *Gıda*, 47(2), 277–295. <https://doi.org/10.15237/GIDA.GD21152>
- Güven, M. & Karaca, O. B. (2002). The effects of varying sugar content and fruit concentration on the physical properties of vanilla and fruit ice-cream-type frozen yogurts. *International Journal of Dairy Technology*, 55(1), 27–31. <https://doi.org/10.1046/j.1471-0307.2002.00034.x>
- Kurt, A. & Atalar, I. (2018). Effects of quince seed on the rheological, structural and sensory characteristics of ice cream. *Food Hydrocolloids*, 82, 186–195. <https://doi.org/10.1016/j.foodhyd.2018.04.011>
- Manikanta, M., Rana, A. & Inamder, A. A. (2023). Utilization of wheat milling industry by-products for value added product development (Ice cream cone). *Tha Pharma Innovation*, 12(2), 3679–3683. www.thepharmajournal.com
- McLellan, M. R., Lind, L. R. & Kime, R. W. (1995). Hue angle determinations and statistical analysis for multi-quadrant Hunter L, a, b data. *Journal of Food Quality*, 18(3), 235–240.
- Meilgaard, M. C., Carr, B. T., & Civille, G. V. (1999). Sensory evaluation techniques (3rd ed.): CRC Pres, Inc. <https://doi.org/10.1017/S1431927611002686>
- Metin, M. (2009). *Süt ve Mamulleri Analiz Yöntemleri*. EÜ, Ege Meslek Yüksekokulu Yay. No: 24.
- Moolwong, J., Klinthong, W. & Chuacharoen, T. (2023). Physicochemical Properties, Antioxidant Capacity, and Consumer Acceptability of Ice Cream Incorporated with Avocado (Persea Americana Mill.) Pulp. *Polish Journal of Food and Nutrition Sciences*, 73(3), 289–296. <https://doi.org/10.31883/PJFNS/170938>
- Onipe, O. O., Jideani, A. I. O. & Beswa, D. (2015). Composition and functionality of wheat bran and its application in some cereal food products. *International Journal of Food Science and Technology*, 50(12), 2509–2518. <https://doi.org/10.1111/ijfs.12935>
- Öztürk-Yalçın, F., Ürkek, B. & Şengül, M. (2024). Evaluation of microbiological, antioxidant, thermal, rheological and sensory properties of ice cream fermented with kefir culture and flavored with mint (Menthaspicata L.). *Food Science and Nutrition*, 12(10), 7358–7369. <https://doi.org/10.1002/fsn3.4355>
- Qayyum, A., Huma, N., Sameen, A., Siddiq, A. & Munir, M. (2017). Impact of watermelon seed flour on the physico-chemical and sensory characteristics of ice cream. *Journal of Food Processing and Preservation*, 41(6), e13297. <https://doi.org/10.1111/JFPP.13297>
- Saini, P., Islam, M., Das, R., Shekhar, S., Sinha, A. S. K. & Prasad, K. (2023). Wheat bran as potential source of

- dietary fiber: Prospects and challenges. *Journal of Food Composition and Analysis*, 116(August 2022), 105030. <https://doi.org/10.1016/j.jfca.2022.105030>
- Salem, S. A., Hamad, E. M. & Ashoush, I. S. (2016). Effect of Partial Fat Replacement by Whey Protein, Oat, Wheat Germ and Modified Starch on Sensory Properties, Viscosity and Antioxidant Activity of Reduced Fat Ice Cream. *Food and Nutrition Sciences*, 07(06), 397–404. <https://doi.org/10.4236/FNS-2016.76041>
- Sayar, E., Şengül, M. & Ürkek, B. (2022). Antioxidant capacity and rheological, textural properties of ice cream produced from camel's milk with blueberry. *Journal of Food Processing and Preservation*, October 2021, 1–8. <https://doi.org/10.1111/jfpp.16346>
- Shehata, M. G., Abd El-Aziz, N. M., Darwish, A. G. & El-Sohaimy, S. A. (2022). Lacticaseibacillus paracasei KC39 Immobilized on Prebiotic Wheat Bran to Manufacture Functional Soft White Cheese. *Fermentation*, 8(10). <https://doi.org/10.3390/fermentation8100496>
- Soukoulis, C., Fisk, I. D. & Bohn, T. (2014). Ice cream as a vehicle for incorporating health-promoting ingredients: Conceptualization and overview of quality and storage stability. *Comprehensive Reviews in Food Science and Food Safety*, 13(4), 627–655. <https://doi.org/10.1111/1541-4337.12083>
- Soukoulis, C., Lebesi, D. & Tzia, C. (2009). Enrichment of ice cream with dietary fibre: Effects on rheological properties, ice crystallisation and glass transition phenomena. *Food Chemistry*, 115(2), 665–671. <https://doi.org/10.1016/J.FOODCHEM.2008.12.070>
- Steffe, J. F. (1967): Rheological Methods in Food Process Engineering. Freeman Press, MI, USA
- Stevenson, L., Phillips, F., O'sullivan, K. & Walton, J. (2012). Wheat bran: Its composition and benefits to health, a European perspective. *International Journal of Food Sciences and Nutrition*, 63(8), 1001–1013. <https://doi.org/10.3109/09637486.2012.687366>
- Sztupecki, W., Rhazi, L., Depeint, F. & Aussenac, T. (2023). Functional and Nutritional Characteristics of Natural or Modified Wheat Bran Non-Starch Polysaccharides: A Literature Review. In *Foods* (Vol. 12, Issue 14). <https://doi.org/10.3390/foods12142693>
- Terpou, A., Gialleli, A. I., Bekatorou, A., Dimitrellou, D., Ganatsios, V., Barouni, E., Koutinas, A. A. & Kanellaki, M. (2017). Sour milk production by wheat bran supported probiotic biocatalyst as starter culture. *Food and Bioprocesses Processing*, 101, 184–192. <https://doi.org/10.1016/j.fbp.2016.11.007>
- Trivedi, V. B., Prajapati, J. P., Pinto, S. V. & Darji, V. B. (2014). Use of basil (tulsi) as flavouring ingredient in the manufacture of ice cream. *American International Journal of Contemporary Scientific Research*, 1(3). www.americanij.com
- Ürkek, B. (2021). Effects of the addition of rose hip on various nutritional and quality properties of ice cream. *Indian Journal of Traditional Knowledge*, 20(October), 1022–1030.
- Ürkek, B. (2025). Physicochemical, rheological properties, antioxidant activity and mineral amount of the ice cream containing barberry (*Berberis vulgaris* L.). *Gümüşhane University Journal of Science*, 15(2), 486–496. <https://doi.org/10.17714/gumusfenbil.1628312>
- Ürkek, B., Gürmeriç, H. E. & Şengül, M. (2021). Chia (*Salvia hispanica* L.) ilavesinin dondurmanın fizikokimyasal ve duyuşsal özelliklerine etkisi. *GIDA / THE JOURNAL OF FOOD*, 46(1), 180–189. <https://doi.org/10.15237-/gida.gd20125>
- Ürkek, B., Gürmeriç, H. E., Şengül, M. & Baltacı, C. (2022a). Preliminary investigations of ice creams for the determination of the physico- chemical properties and aroma compounds by GC-MS produced from cow, sheep, goat, and buffalo milk. *FJournal of Food Safety and Food Quality*, 73(4), 120–127. <https://doi.org/10.2376/0003-925X-72-120>
- Ürkek, B., Öztürk, F. & Şengül, M. (2022b). Farklı bitki tozlarının (üzüm çekirdeği, keçiyoynuzu ve çörekotu tozu) dondurma üretiminde kullanım imkanları. *ATA-Gıda Dergisi*, 1(1 (Ocak)). <https://dergipark.org.tr/tr/pub/atafoodj/issue/71350/1147398>
- Van Hung, P. (2016). Phenolic Compounds of Cereals and Their Antioxidant Capacity. *Critical Reviews in Food Science and Nutrition*, 56(1), 25–35. <https://doi.org/10.1080/10408398.2012.708909>
- Wang, B., Li, G., Li, L., Zhang, M., Yang, T., Xu, Z. & Qin, T. (2024). Novel processing strategies to enhance the bioaccessibility and bioavailability of functional components in wheat bran. *Critical Reviews in Food Science and Nutrition*, 64(10), 3044–3058. <https://doi.org/10.1080/10408398.2022.2129582>