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Characteristics of ice cream from black soybean sprout juice – red dragon fruit with yolk emulsifier

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ABSTRACT

Black soybean germination into sprouts reportedly improved nutrition digestibility and bioactive compound content. Red dragon fruit (RDF) and egg yolk (EY) can be used as natural and halal colorants and emulsifiers. Black soybean sprout (BSS) juice made non-dairy ice cream with red dragon fruit and egg yolk as an emulsifier. This research aimed to measure the effect of various red dragon fruit and egg yolk concentrations on the characteristics of ice cream made from BSS juice. A completely randomized design was applied to six formulations made using the ratio of RDF : EY of FA (20%: 3%), FB (20%: 4%), FC (20%: 5%), FD (40%: 3%), FE (40%: 4%), and FF (40%: 5%). BSS juice was made using 48 hours of room temperature incubated sprout and water at a 1:4 (b/v) ratio. Filtrate was then mixed with sugar, cornstarch, and salt into a dough, which was then mixed with RDF and EY at various concentrations. Nutritional proximate composition, radical scavenging activity, phenolic content, total anthocyanin content, vitamin C, and sensory acceptance were analyzed. Data was then statistically analyzed using one-way ANOVA, followed by Duncan's Multiple Range Test. Results showed that higher RDF significantly changed overrun, melting rate, increased moisture content, vitamin C (20.4 – 40.23 mg/100 g), antioxidant activity (34.9 – 62.78 % radical scavenging activity), total phenolics (0.341 – 0.536 mg/g GAE), and total anthocyanin (3.905 – 9.726 mg/kg), and hedonic score, but shorter melting time. The shortest melting time was obtained by ice cream made using 20% RDF and 5% EY, the lower concentration of fruit, and the highest concentration of egg yolk, respectively. The results indicated that BSS juice could be used as the main ingredient to make non-dairy ice cream, with red dragon fruit and egg yolk as natural colorants and emulsifiers, respectively.

Keywords: Black soybean sprout, Non-dairy ice cream, Red dragon fruit

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INTRODUCTION

Soybean is a legume with a high protein and fat content of 30.53% and 7.5% – 20.9%, respectively (Mardiyanto & Sudarwati, 2015). Among colored legumes, black soybeans contain anthocyanins that have antioxidant functions (Nurrahman, 2015). Like many legumes, black soybean also contains antinutrients such as phytic acid and tannin, which can be reduced to around two-thirds of fresh beans by processing, such as germination (Chauhan et al., 2022). Besides eliminating the unpleasant taste of soybeans, germination also increases bioactive compounds (Aminah, 2020). Germination increases the isoflavone content of black soybean (Ren et al., 2017), which is known to prevent osteoporosis, cancer prevention, cardiovascular diseases, and menopausal symptoms (Suhaimi et al., 2023).

Sprout from germination can be directly cooked or consumed and processed into sprout juice. Black soybean sprout juice can be a better alternative, more practical product, and easier to consume. It can also be used as an alternative for non-dairy beverages or as an alternative ingredient for products usually made from dairy, such as ice cream. Ice cream is made of a complex colloidal frozen system that is composed of partially coalesced fat droplets, ice crystals, air cells, solids, and continuous aqueous

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in which the polysaccharides, protein, sugar, and salts are dispersed (Goff & Hartel, 2013). Ice cream is a type of semi-solid food popular due to its sweet taste, soft texture, and melting ability in the mouth (Haryanti & Zueni, 2015). However, ice cream made from milk is not suitable for consumption by people with lactose intolerance. Non-dairy coconut milk or legume juice can be an alternative. However, this also has its inadequacy, as the formation of an emulsion determines ice cream's physical and sensory quality. The emulsion content in non-dairy ice cream is lower than in dairy-made ice cream. The difference between soymilk and dairy milk is the type of amino acid in the form of casein and the pleasant smell (Mardiyanto & Sudarwati, 2015). Therefore, the role of emulsifiers is critical in non-dairy ice cream.

Animal-based emulsifiers have been widely used in the food industry. However, some animal-derived emulsifiers can be doubtful in halal aspects. Therefore, egg yolk can be used as a natural emulsifier alternative as it contains lecithin, an emulsifying agent. Egg yolk significantly determines ice cream texture by enhancing water retention and improving viscosity, preventing ice cream separation (Gouda et al., 2021). The addition of egg yolk at a concentration of 0.3 – 0.5% has a lecithin content with a hydrophile lipophile balance (HLB) value of 5 – 8, which is an efficient addition. The higher the HLB value, the more soluble it is in fat, while the lower the HLB value, the increasingly soluble in water (Iteh, 2012). This is to a previous report that the average use of 0.1 – 0.5% emulsion is expected to maintain the fat emulsion's stability in ice cream during storage in the freezer (Violisa et al., 2012).

In addition to emulsifiers, another aspect is color. Red dragon fruit can be added as an alternative to improve the quality and interest in ice cream products to improve the quality and color of ice cream. Previous research suggested that adding 20% or 40% dragon fruit can improve the quality of the aroma and color of ice cream products (Umar et al., 2019). Red dragon fruit (*Hylocereus polyrhizus*), recognized as a distinct red dragon-like shape peel and red flesh, contains several compounds with health benefits. Betalain, betacyanin, β-carotene, lycopene, flavonoids, and anthocyanin are some of the bioactive compounds found in *H. polyrhizus*, which not only responsible for the bright color of the fruit color but also demonstrate the antioxidative activity with various health benefits, such as prevention of cardiovascular disease, exert anti-inflammatory actions in gastrointestinal, etc. (Nishikito et al., 2023). The fruit has been used as a natural colorant in several products, such as fruit jelly (Glangkarn, 2015), Velva (Nurjanah et al., 2020), fish nugget (Hasri et al., 2021), and ice cream (Fadmawati et al., 2019; Hafids et al., 2019; Isral et al., 2023; Umar et al., 2019). It has reportedly improved color acceptance and added the “body” of ice cream, even in low-fat ice cream (Hafids et al., 2019). Its vitamin content and fiber might also increase the product's functionality, such as (Fadmawati et al., 2019).

However, all the previous ice cream that used red dragon fruit were made using dairy-based main ingredients. There is minimal information or research on red dragon fruit utilization for non-dairy ice cream, especially since usually the non-dairy ingredient has lower protein and fat content, two main aspects of making suitable emulsion. Even more limited information exists on non-dairy ice cream, primarily made using black soybean sprouts with egg yolk as an emulsifier. Based on the background above, research will be carried out to examine the formulation of ice cream made from black soybean sprout extract with egg yolk emulsifier and the addition of red dragon fruit as a natural coloring. On a hedonic scale, an analysis was conducted on proximate content, antioxidant activity, total phenolics, anthocyanins, vitamin C, melting speed, overrun, and sensory evaluation.

RESEARCH METHOD

Materials

The materials used in this research include black soybeans, chicken egg yolk, corn starch, sugar, and salt, all bought from local markets. Other materials for analysis were N catalyst, concentrated H_2SO_4, distilled water, boric acid, Na-borate, BCG-MR indicator, and concentrated HCl (Sigma Aldrich). Equipment used in this research includes basins, pans, stoves, blender (Philip HR 2116, 600 W), mixer (Philip HR 1552), stirrers, cups, freezer (GEA SD-103), scales, a set of Soxhlet apparatus, oven, desiccator, a set of distillation apparatus, tube clamps, measuring flasks, measuring pipettes, spray bottles, burette, stative, Erlenmeyer, and dropper pipette.

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Methods

1. Black soybean sprout juice preparation

   According to previous research, germination was conducted with modification (Chauhan et al., 2022). After selection and cleaning, black soybeans were soaked for 8 hours to increase water content and soften black soybean seeds. After draining, beans were incubated for 48 hours on a broad basket covered with a wet cloth and kept in a dark room with proper air circulation. Once, after 24 hours of incubation, all parts of the seeds were water–sprayed in a push in each section. After 48 hours, the length of the sprouts was around 2 – 3 cm. Sprout juice was prepared according to previous research (Mardiyanto & Sudarwati, 2015) with slight modifications. Sprouts were washed and ground using a blender with warm water (65°C), beans, and a water ratio 4:1 for 2 minutes. After filtration, the juice was put in a previously sterilized close-capped bottle.

2. Ice cream preparation

   Dragon fruit flesh was separated from the skin and then mashed into pulp. Ice cream was prepared by mixing black soybean sprout juice with sugar, salt, and corn starch at 73%, 25%, 0.5%, and 1.5%, respectively. After mixing in a blender, the mixture was cooled and pasteurized at 80°C for 5 minutes. Red dragon fruit (RDF) pulp and egg yolk (EY) were then added at various ratios of RDF: EY of FA (20%:3%), FB (20%:4%), FC (20%:5%), FD (40%:3%), FE (40%:4%), and FF (40%:5%) as shown in Table 1. Agitation (15 minutes) was carried out using a hand mixer, followed by freezing (8 hours) and second agitation (15 minutes). Finally, each ice cream mixture was placed in cups according to formulation and frozen for at least 24 hours before analyses.

Table 1. Formulation of black soybean sprout juice – red dragon fruit ice cream with egg yolk emulsifier.

Sample code	Red dragon fuit (%w/w)	Egg yolk (%w/w)	Black soybean sprout juice mixture (%w/w)	Total weight
FA	20	3	77	100%
FB		4	76	
FC		5	75	
FD	40	3	57	
FE		4	56	
FF		5	55	

3. Melting rate and overrun

   Melting rate is the weight or volume of ice cream that melts at room temperature per specific unit of time. At the same time, overrun is the increasing volume or volume of mixture to ice cream due to air incorporation during agitation. The analyses were done using a modified method (Muse & Hartel, 2004). Room temperature, relative humidity, and the weight of two beakers were previously measured (26°C, RH 80%). About 100 grams of ice cream that had been frozen for 24 hours were taken in triplicate, placed in a beaker positioned tilted towards another empty beaker and allowed to melt at room temperature. The weight of the melted sample droplets in the second beaker was measured. The time (minute) was plotted against the dripped weight (g), and the slope of the main melting event was taken as the melting rate. To measure overrun, the volume of 100 g of mixture of each formulation in triplicate was measured before the first and after the second agitation. Overrun was calculated as the volume difference between the mixture and ice cream divided by those of the latter, multiplied by 100.

4. Proximate analyses

   Proximate analyses on moisture, ash, protein, fat, and total carbohydrates were carried out according to the official method by the Association of Official Analytical Chemists (AOAC

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International et al., 2011). Moisture and ash content was measured using thermogravimetry and oven method, respectively. Protein was measured using micro-Kjeldahl, while fat was measured using Soxhlet extraction. Carbohydrate was measured by difference.

5. Antioxidant analyses

The analyses include antioxidant activity, phenolic content, anthocyanin, and ascorbic acid content. Antioxidant activity was measured using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging method using methanol as solvent, based on previous research on dragon fruit (Choo & Yong, 2011), with slight modification. Approximately 1 mL sample was added to 2 mL DPPH solution (2 mL of 0.02g/L DPPH) in methanol. Then, the absorbance was measured at 517 nm against a blank assay after 30 minutes of dark room incubation. The percentage of radical scavenging activity (%RSA) was measured by reduction results between sample and blank absorbance divided by that of blank at the same time multiplied by 100. Total phenolic content (TPC) analysis in this study used Folin-Ciocalteu analysis expressed as GAE (gallic acid equivalent) based on the previous method (Ramadhan et al., 2023) with modification. Approximately 0.3 mL samples were put into test tubes and then added with 1.0 mL of Folin-Ciocalteu reagent (made by 10 times dilution with water) and 1.2 mL of Na carbonate (7.5% w/v). After vortexing and 30 minutes of incubation, absorbance at 765 nm was measured against a reagent blank. A standard calibration curve was prepared using gallic acid.

Total anthocyanins were measured using the pH differential method according to the previous method (Hsieh-Lo et al., 2020), expressed as cyanidin-3-glucoside equivalent. Each sample (0.1 mL) was divided into two test tubes, and each was diluted to a factor of 1:100 v/v with potassium chloride (pH 1.0, 0.025 M) and sodium acetate (pH 4.5, 0.4 M). The absorbance of samples at each pH was read at 520 and 700 nm. Total anthocyanin was calculated by reduction of absorbance taken at 520 nm to those of 700 nm from pH 1, then reduced by similar calculation from pH 4.5. The number obtained was multiplied by molecular mass of cyd-3-glu (449.2 g/mol), dilution factor (100), and conversion factor from gram to milligram (10), then divided by extinction coefficient (26900 L $mol^{-1}cm^{-1}$). Results were expressed as mg of cyanidin-3-glucoside equivalents per 100 g sample (mg C3GE/100 g).

Vitamin C as ascorbic acid content was measured using the iodine titration method (Choo & Yong, 2011), using starch as an indicator prepared by mixing 1g of starch with 200 mL of boiling water. For analysis, each 25 mL sample was put into a 250 mL Erlenmeyer flask, added with 25 mL of 2 N sulfuric acid, mixed, and diluted with 50 mL water and 3 mL starch indicator solution. Titration was conducted using 0.001 N standardized iodine solution, with blank titration prior to each sample titration. Ascorbic acid was calculated based on 1 mL of 0.001N iodine equivalence to 88.06 µg ascorbic acid.

6. Sensory analysis

Sensory analyses were conducted using the method described in Indonesia National Standard (BSN, 2006), using a structured intensity score (1 – 10) and hedonic score (1 – 7; 1 = dislike very much, 2 = dislike, 3 = moderately dislike, 4 = neutral, 5 = moderately like, 6 = like, 7 = like very much). Analysis was conducted on 35 healthy panelists (21 females, 14 males, age range of 19 – 38 years old) on parameters of taste, beany flavor, color, mouthfeel, viscosity, and aftertaste, who were also asked to comment on samples.

Data Analysis

All data in triplicate was then analyzed using an ANOVA test with a significant level of 95%, followed by Duncan's test to measure significance (Isral et al., 2023).

RESULT AND DISCUSSION

Physical properties

Black soybean sprout juice and red dragon fruit share similarities in that both contain high moisture content and bioactive compounds (Hasri et al., 2021; Ren et al., 2017). Their combination with

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non-dairy ice cream can be a healthier alternative for those with lactose intolerance. The utilization of egg yolk as a natural emulsifier is also a better alternative in terms of the halal aspect, as eggs without any processing are classified into a positive list released by Majelis Ulama Indonesia (SK12/Dir/LPPOM MUI/V1/20). However, since both also have low-fat levels compared to full-cream dairy, usually used as the primary material in ice cream, physical properties such as melting rate and overrun might be affected.

Table 2. Melting rate and overrun of black soybean sprout juice – red dragon fruit ice cream with egg yolk emulsifier.

Sample Code	RDF (%)	EY (%)	Physical characteristics	
			Melting rate (g/min)	Overrun (%)
FA	20	3	1.04 ± 0.02^{ab}	44.94 ± 0.23^{b}
FB		4	1.60 ± 0.01^{b}	54.75 ± 0.18^{c}
FC		5	0.86 ± 0.02^{a}	55.00 ± 0.11^{d}
FD	40	3	3.30 ± 0.01^{d}	31.25 ± 0.21^{a}
FE		4	1.38 ± 0.01^{b}	54.43 ± 0.17^{c}
FF		5	2.66 ± 0.03^{c}	54.81 ± 0.25^{c}

Results are expressed as mean ± SD. Different superscripts (a, b, c, d) in a column show significant differences ($P < 0.05$); RDF: red dragon fruit; EY: egg yolk.

The emulsifier components in egg yolk are phospholipids, lipoproteins, and proteins. Egg yolk contains surface active parts: lecithin, cholesterol, and lecithoprotein. Egg yolk has strong emulsifier power due to lecithin, a phospholipid found in a complex form as lecithin-protein. Lecithin in egg yolk is an emulsifier that can bind water and fat. Lecithin has two groups: hydrophilic (polar side) and lipophilic (non-polar side). This polar group tends to dissolve in water, while the non-polar groups found in fatty acid esters dissolve in fat or oil. Moreover, lipoproteins in egg yolk also act as an emulsion stabilizer due to their ability to interact on the surface of fat globules to form a protective layer (Gouda et al., 2021).

Results showed that RDF concentrations might change melting rate and overrun. The melting rate was significantly reduced in lower RDF but still comparably higher in 40% RDF. However, since there is only a slight difference in egg yolk concentration, the results might not be due to the EY level. The results indicated that lower RDF and higher EY might be suitable for producing a low melting rate and high overrun of black soybean sprout juice-based non-dairy ice cream. FC at lower red dragon fruit (20%) and highest egg yolk (5%) had the lowest melting rate and highest overrun (Table 2). The melting rate is related to fat destabilization, which forms clumps of fat globules that envelope and support the air cells while maintaining the fat network that builds the “body” of ice cream. The higher the destabilized fat, the lower the melting rate (Muse & Hartel, 2004). It is also related to solid material contained in the mixture (Hafids et al., 2019). Formulation suggested that a higher concentration of red dragon fruit and egg yolk decreased the mixture's solid, consisting of black soybean sprout juice and starch. Starch can function as a fat replacer to a certain level, but the concentration of egg yolk plays a vital part. Though FC had a lower mixture percentage (75% w/w) than FA and FB (77% and 76%, respectively), it had the highest egg yolk concentration that might support the emulsion and prevent water loss. Previous research suggested that higher red dragon fruit might lengthen the melting time of ice cream due to solids in the ice cream, both in the utilization of 1.5% duck egg and chicken egg as an emulsifier (Isral et al., 2023). However, the ice cream in that research used full-cream milk, dairy whipped cream, and vegetable cream as the main ingredients, which is very different from this study. The results suggested using around 20% red dragon fruit and 5% egg yolk as emulsifiers in the non-dairy, non-cream ice cream is better.

The recommended standard of overrun value for the household scale is 35-50%, while for the industrial scale is 70-80% (Hafids et al., 2019). The results from this study suggested that all formulations can be used to produce ice cream based on overrun value, except the FD (40% RDF and 3% EY). In the RDF comparison, the higher fruit pulp concentration resulted in a lower overrun (Table

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2). The solids in the fruit probably cause this. Previous research suggested that higher starch utilization decreases overrun due to higher viscous components that prevent air incorporation. The thicker the ice cream mix causes more considerable surface tension, making it difficult for the air to penetrate the ice cream's surface and causing poor ice cream development (Haryanti & Zueni, 2015). Therefore, FD, FE, and FF at higher fruit pulp with lower mixture weight and lower corn starch content had comparable overruns to those of lower fruit pulp (Table 2). However, the emulsion that withstands the air cells must also be supported by sufficient emulsifier, especially in non-dairy, non-cream ice cream. Otherwise, the air cell cannot be built properly, hence the lower overrun in FD.

Proximate properties

Table 3. Proximate black soybean sprout juice composition – red dragon fruit ice cream with egg yolk emulsifier.

Sample Code	RDF (%)	EY (%)	Proximate composition (% wb)				
			Moisture	Ash	Protein	Fat	Carbohydrate*
FA		3	76.80 ± 0.05[ab]	0.55 ± 0.04[a]	1.92 ± 0.04[a]	1.36 ± 0.02[a]	19.37 ± 0.11[e]
FB	20	4	76.89 ± 0.12[b]	0.52 ± 0.01[a]	1.94 ± 0.04[ab]	1.66 ± 0.12[b]	18.98 ± 0.23[d]
FC		5	76.66 ± 0.11[a]	0.55 ± 0.02[a]	2.26 ± 0.02[d]	1.90 ± 0.08[c]	18.64 ± 0.15[c]
FD		3	77.68 ± 0.12[c]	0.53 ± 0.01[a]	2.00 ± 0.01[b]	1.45 ± 0.03[a]	18.35 ± 0.10[b]
FE	40	4	78.87 ± 0.03[e]	0.51 ± 0.10[a]	1.94 ± 0.03[ab]	1.57 ± 0.06[b]	17.10 ± 0.04[a]
FF		5	78.12 ± 0.04[d]	0.54 ± 0.07[a]	2.15 ± 0.05[c]	2.24 ± 0.02[d]	16.95 ± 0.11[a]

Results are expressed as mean ± SD. Different superscripts (a, b, c, d) in a column show significant difference ($P < 0.05$); RDF: red dragon fruit; EY: egg yolk
*By difference

The concentration difference between red dragon fruit and egg yolk also resulted in significant differences in several proximate compositions, such as moisture, protein, fat, and carbohydrate (by difference). Higher red dragon fruit, egg yolk, and a reduced black soybean sprout and corn starch significantly increased the ice cream's moisture, protein, and fat content and consequently lower carbohydrates (Table 3). Higher moisture content was significantly affected by red dragon fruit, as the fruit has a high moisture of 82 – 83% (Choo & Yong, 2011). On the other hand, protein and fat shared a similar pattern, in which RDF difference relatively had no effect, whereas EY had a significant effect on protein and fat. This was due to the high fat and protein content in chicken eggs. Chicken egg has 12.6% and 9.5% protein and fat content per 100 whole eggs, respectively. The yolk itself contains 15,9% protein (Réhault-Godbert et al., 2019) and around 31% fat, while red dragon fruit only has around 0.15 – 0.22 g protein and around 0.17 g fat per 100 g (Choo & Yong, 2011). However, the product's limitation was the protein and fat content, which was lower than the standards in the Indonesia National Standard (SNI 3713:2018) of ice cream. These results suggested that egg yolk is essential to non-dairy ice cream, retaining protein and fat content. The two components are critical for other aspects of ice cream, such as physical and sensory properties.

Antioxidant properties

In this study, ice cream was made using main ingredients with bioactive compounds and potent antioxidant activity, according to previous research. Black soybean sprouts with peel contain isoflavone in glycone and aglycone forms, such as daidzin, genistin, daidzein, and genistein (Ren et al., 2017), and also anthocyanin, with increasing polyphenolic content due to germination (Chauhan et al., 2022). Ascorbic acid was also reportedly detected in germinated black soybeans but not raw beans (Aminah, 2020). Red dragon fruit is also high in antioxidant compounds with health benefits (Nishikito et al., 2023). However, sprout juice and ice cream processing in this study might change the antioxidant compounds or reduce the amount of them that can be retained in the final product. Therefore, the final products' antioxidant activity, phenolics, anthocyanin, and ascorbic content were measured.

Based on the results (Table 4), a higher concentration of red dragon fruit increased antioxidant activity as well as total anthocyanin and ascorbic acid content. The highest was those made using 40%

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red dragon fruit; the lowest was black soybean sprout juice. These results suggested that BSS processing into juice, which consists of water extraction and pasteurization, reduced the antioxidant properties of black soybeans. Moreover, the ratio of material and water was 1:4, reducing the amount of extracted antioxidant compound. Water extraction as the by-default process in making the juice is not a preferable option for black soybean extraction (González-Montoya et al., 2018; Kuligowski et al., 2016; Wu et al., 2017). Germination reportedly increased antioxidant activity and phenolics but reduced anthocyanin (Chauhan et al., 2022). Total anthocyanin was increased with the higher concentration of red dragon fruit, suggesting that red dragon fruit can be a source of this compound.

Table 4. Antioxidant activity, total phenolics, total anthocyanin, and ascorbic acid content of black soybean sprout juice – red dragon fruit ice cream with egg yolk emulsifier.

Sample Code	RDF (%)	EY (%)	Antioxidant activity (% RSA)	Total phenolics (mg GAE/100 g)	Total anthocyanin (mg C3GE/100 g)	Ascorbic acid (mg/100 g)
FA	20	3	34.88 ± 0.11[a]	34.10 ± 0.45[a]	0.39 ± 0.04[a]	20.41 ± 3.40[a]
FB		4	36.29 ± 0.17[b]	36.80 ± 0.46[b]	0.53 ± 0.04[b]	27.35 ± 3.42[bc]
FC		5	37.76 ± 0.11[c]	40.80 ± 0.45[c]	0.65 ± 0.02[c]	26.17 ± 3.27[ab]
FD	40	3	56.15 ± 0.11[d]	53.60 ± 0.29[f]	0.71 ± 0.03[d]	31.35 ± 3.48[bc]
FE		4	59.80 ± 0.11[e]	47.40 ± 0.30[e]	0.90 ± 0.03[e]	33.30 ± 3.33[c]
FF		5	62.79 ± 0.11[f]	45.20 ± 0.45[d]	0.97 ± 0.03[f]	40.23 ± 3.35[d]

Results are expressed as mean ± SD. Different superscript (a, b, c, d) in a column show significant differences ($P < 0.05$); RDF: red dragon fruit; EY: egg yolk; %RSA: percent of radical scavenging activity; GAE: gallic acid equivalent.

Anthocyanin content of the ice cream in this study (Table 4) was shallow compared to those reported in previous research on red dragon fruit and germinated black soybean (González-Montoya et al., 2018; Ren et al., 2017; Yadnya & Putra, 2023). It can be due to the effect of heating during processing. Research also mentioned that utilization of heating temperature (80°C) was detrimental to the antioxidant properties of products made from dragon fruit, compared to those at a lower temperature of 60 °C and 70°C (Glangkarn, 2015). Interestingly, the highest total phenolics content was found in sample code FD with 40% red dragon fruit and decreased with the decrease of black soybean sprout juice as egg yolk content increased (FE and FF). The results indicated that the combination of 40% RDF and around 42% BSS probably had the highest yield of total phenolics. However, the highest antioxidant activity, total anthocyanin, and ascorbic acid suggested that the highest RDF and lowest BSS were preferable. Previous research reported that *H. polyrhizus* has around 32.65 mg/100 g of ascorbic acid (Choo & Yong, 2011). This study's increasing ascorbic acid content probably came from the combination of red dragon fruit and black soybean sprout juice.

Sensory properties

Sensory analysis in this study was conducted using two methods: intensity score (scale 1 – 10) and hedonic score (1 – 7). The first was done to measure the strength of perception received by the panelist of the parameters analyzed since the ice cream was made using non-dairy ingredients with distinct beany flavors. At the same time, the second was measured to see the likability of the products by panelists.

Intensity scores showed that the difference between red dragon fruit, egg yolk, and black soybean sprout juice had no significant difference in taste, mouthfeel, beany flavor, and aftertaste (Table 5). The results showed that increasing RDF increased color acceptance as the red-purplish color became more intense, as also perceived by the panelists. Another aspect that was perceived as different was viscosity. The higher the red dragon fruit, the lower the product's viscosity. This can be due to the higher moisture content of the product (Table 3). Previous research by Hafids et al. (2019) also reported that higher red dragon fruit peel substitution in low-fat ice cream resulted in lower viscosity when measured with a viscometer. The results also suggested that a higher concentration of egg yolk did not affect the viscosity perceived by panelists and other sensory parameters. The fishy smell of eggs was not apparent, probably

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due to red dragon fruit and black soybean sprout juice. Panelists also detected the beany flavor in a concentration-dependent manner, but not significantly different among all samples.

Table 5. A sensory intensity score of black soybean sprout juice – red dragon fruit ice cream with egg yolk emulsifier.

Sample Code	RDF (%)	EY (%)	Color	Taste	Mouthfeel	Viscosity	Beany flavor	Aftertaste
FA		3	6.30 ± 2.31^{b}	7.43 ± 2.24^{a}	6.57 ± 1.99^{a}	5.87 ± 2.39^{b}	6.27 ± 2.33^{a}	6.17 ± 2.63^{a}
FB	20	4	6.93 ± 2.29^{bc}	6.50 ± 2.00^{a}	5.80 ± 2.48^{a}	5.20 ± 2.40^{ab}	6.27 ± 2.48^{a}	5.87 ± 2.60^{a}
FC		5	5.00 ± 2.52^{a}	6.33 ± 2.20^{a}	5.57 ± 2.49^{a}	5.70 ± 2.38^{b}	6.20 ± 2.06^{a}	5.83 ± 2.44^{a}
FD		3	7.63 ± 1.69^{c}	6.67 ± 2.11^{a}	6.43 ± 2.22^{a}	4.93 ± 2.35^{ab}	5.70 ± 2.25^{a}	6.60 ± 2.40^{a}
FE	40	4	8.00 ± 1.64^{c}	6.87 ± 2.10^{a}	5.90 ± 2.68^{a}	4.20 ± 2.12^{a}	5.43 ± 2.30^{a}	5.97 ± 2.65^{a}
FF		5	8.03 ± 1.83^{c}	6.33 ± 2.26^{a}	6.07 ± 2.96^{a}	4.27 ± 2.16^{b}	5.30 ± 2.17^{a}	5.93 ± 2.52^{a}

Intensity score (1 – 10). Results are expressed as mean ± SD. Different superscript (a, b, c, d) in a column show significant differences (P < 0.05). RDF: red dragon fruit; EY: egg yolk

Table 6. A hedonic score of black soybean sprout juice – red dragon fruit ice cream with egg yolk emulsifier.

Sample Code	RDF (%)	EY (%)	Color	Taste	Mouthfeel	Viscosity	Beany flavor	Aftertaste
FA		3	4.75 ± 1.05^{a}	4.43 ± 1.47^{a}	4.78 ± 1.18^{ab}	4.55 ± 1.4^{ab}	4.05 ± 1.22^{ab}	4.24 ± 1.38^{ab}
FB	20	4	5.10 ± 1.22^{b}	4.17 ± 1.28^{a}	4.12 ± 1.11^{a}	4.24 ± 1.3^{ab}	3.93 ± 1.19^{ab}	3.77 ± 1.33^{a}
FC		5	5.15 ± 1.44^{b}	4.40 ± 1.41^{a}	4.52 ± 1.28^{ab}	4.08 ± 1.36^{a}	3.77 ± 1.33^{a}	4.17 ± 1.36^{ab}
FD		3	5.87 ± 0.89^{c}	4.63 ± 1.13^{ab}	4.90 ± 1.40^{bc}	4.94 ± 1.28^{bc}	4.24 ± 1.47^{ab}	4.59 ± 1.20^{bc}
FE	40	4	6.10 ± 0.73^{c}	5.40 ± 0.89^{c}	5.48 ± 1.09^{cd}	5.10 ± 0.93^{cd}	4.67 ± 1.15^{bc}	5.05 ± 0.96^{c}
FF		5	6.15 ± 1.01^{c}	5.29 ± 0.90^{bc}	5.72 ± 0.88^{d}	5.37 ± 0.97^{d}	4.87 ± 1.12^{c}	4.94 ± 1.19^{bc}

Hedonic score (1 – 7; 1 = dislike very much, 2 = dislike, 3 = moderately dislike, 4 = neutral, 5 = moderately like, 6 = like, 7 = like very much). Results are expressed as mean ± SD. Different superscript (a, b, c, d) in a column show significant differences (P < 0.05). RDF: red dragon fruit; EY: egg yolk

A hedonic score of ice cream in this study ranged from neutral to like (4.08 – 6.15) for color, taste, mouthfeel, and viscosity. Whereas parameters related to aroma sensation, such as beany flavor and aftertaste, had slightly lower scores from close to neutral to moderately like (3.77 – 4.87), with higher RDF and EY concentration – and consequently lower black soybean sprout juice portion – resulted in higher acceptance (Table 6). The results indicated that the hedonic score of the ice creams in this study significantly depended on the red dragon fruit concentration. A higher concentration of RDF significantly improved panelists' acceptance of color, taste, mouthfeel, viscosity, beany flavor, and aftertaste. These results differed from previous reports (Fadmawati et al., 2019; Hafids et al., 2019), which mentioned that increasing red dragon fruit reduced the acceptance score of ice cream. This can be due to the procedure difference used in the assessment. In this study, unlike previous research, the ice creams were not compared to commercial red dragon ice cream products or those without red dragon fruit. Thus, in this study, panelists could measure the products' likability. This procedure has limitations that cannot measure the comparison between these and commercial products. However, the results were similar to another report (Umar et al., 2019) on sensory hedonic comparison between red dragon fruit ice cream and those without the fruit, which also utilized egg yolk as an emulsifier. The study reported that 10 – 40% of red dragon fruit, in addition to dairy ice cream, significantly improved the hedonic score of color, aroma, texture, and taste compared to 0% of fruit. Research also mentions that 40% of red dragon fruit is the best concentration for improving ice cream sensory acceptance (Isral et al., 2023; Umar et al., 2019). It can be presumed that in non-dairy ice cream, such as in this study, red dragon fruit can be used as a natural colorant alternative to improve sensory hedonic acceptance.

Meanwhile, the difference in egg yolk concentration did not affect the parameters, as seen in no comparable difference among samples in each RDF concentration (Table 6). However, it can be seen that in 40% RDF, increasing egg yolk concentration resulted in higher scores for taste, mouthfeel, and viscosity. According to the comments written by several panelists, despite the slight fishy smell in fresh

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egg yolk utilized, they found no trace of such smell in the final products. Especially in higher red dragon fruit concentration, panelists perceived distinct smoother and better palatability in ice creams added with higher egg yolk concentration. As mentioned in a review (Gouda et al., 2021), the yolk contains lecithin with emulsifying properties, as well as thymol, trans-cinnamaldehyde, and vanillin, which generally used in the ice cream industry to improve sensory quality, such as taste, smell, and rheological properties of emulsions as compared to the commercial stabilizer, due to their low molecular weight and density.

CONCLUSION

Increasing the percentage of red dragon fruit substitution and egg yolk in non-dairy ice cream made from black soybean sprouts increased moisture, fat, and protein. A higher concentration of red dragon fruit also improves antioxidant properties. In comparison, higher egg yolk concentration improves the physical properties of melting rate and overrun, as well as sensory acceptance of the ice cream. Based on the parameters analyzed in this study, the best formulation was obtained from 40% red dragon fruit and 5% egg yolk addition.

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