Original article

# Effect of Beauregard sweet potato paste supplementation on physicochemical and sensory characteristics of soymilk gelato

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**Abstract.** *Background and aim:* Gelato is a frozen dessert that is in demand by many people. Soymilk gelato with the addition of Beauregard Sweet Potato (BSP) paste is a functional gelato innovation. This study aims to determine the effect of different concentrations of BSP paste on the physicochemical and hedonic properties of soymilk gelato. *Methods:* The experimental design used was a Completely Randomized Design (CRD) with 5 treatments and 4 replications, namely 0%, 7.5%, 15%, 22.5%, and 30% BSP paste. The research method consists of experimental design, research procedures, parameter analysis, and data analysis. *Results:* The results showed that soymilk gelato with the addition of BSP paste had a significant ($p<0.05$) effect on the physicochemical and hedonic properties of gelato. The addition of BSP paste increased fiber content, melting time, preference for color, taste, and aroma of gelato, as well as decreased fat content, overrun, and preference for texture. *Conclusions:* The treatment of adding BSP paste as much as 30% was the best treatment.

**Key words:** Beauregard sweet potato, fiber, gelato, overrun, soymilk

## Introduction

Gelato is a frozen dessert from Italy that is widely popular among various groups of people because it is sold in a variety of flavors, has a soft texture, and is served cold. Gelato is made from milk, sugar, fat, eggs, and flavoring agents. Milk contains essential nutrients, contributes to texture softening, enhances flavor, and provides structure to gelato. However, its protein content can trigger allergic reaction (1). The main components that cause allergies are α-casein, kappa casein, and β-lactoglobulin which activate Immunoglobulin E (Ig E), leading to allergic symptoms in the digestive tract (2). The prevalence of milk allergies in Indonesia ranges from 2% to 7.5%. Additionally, milk contains lactose, which cannot be digested by individuals with lactose intolerance due to a lack of enzyme lactase (3). Undigested lactose reaches the colon and undergoes fermentation, producing organic acids and gases that cause symptoms such as abdominal pain, diarrhea, bloating, and cramps. The prevalence of lactose intolerance in Indonesia is 57.9% in children aged 6 – 7 years, 58.9% in children aged 8 – 9 years, and 57.1% in children ages 10 – 12 years (4). Given these concerns, there is a need to develop gelato using lactose- and casein-free ingredients, such as soymilk. Soymilk gelato is plant-based alternative that can be consumed by vegans because it is made from non-dairy ingredients, specifically soymilk. A plant-based diet is characterized by a high fiber and low-fat intake, which is associated with various health benefits (5). Soymilk has a protein composition and amino acid profile comparable to that

of dairy milk but with a lower fat content. Every 100 g of soymilk contains approximately 41 kcal of energy, 3.50 g of protein, 2.50 g of fat, and 5.00 g of carbohydrates (6). Soymilk contains isoflavones, which have functional properties that help prevent cancer, osteoporosis, and atherogenesis (7). Previous studies have developed gelato formulations using soymilk as a dairy substitute to accommodate individuals with milk allergies and lactose intolerance. While this substitution successfully addressed the allergy and intolerance issue, it also resulted in undesirable sensory and physicochemical characteristics, such as an unpleasant aroma, unappealing color, low overrun, poor texture, and fast melting properties (8). Furthermore, soy-based gelato has lower fat and fiber content compared to traditional dairy gelato, affecting its chemical composition and structural properties (9). Therefore, additional ingredients are needed to enhance the physicochemical and sensory properties of soymilk gelato. Previous research has attempted to address these challenges by incorporating ingredients such as beet extract, sweet potato, and ginger extract. The addition of beet extract in ice cream formulations successfully enhanced color due to its betacyanin pigment, which naturally imparts a red hue to the product (10). This pigment also acts as an antioxidant, but the addition of beet extract has not been able to improve the texture and melting time of the ice cream. approach is the incorporation of BSP paste to enhance both the physicochemical and hedonic properties of soymilk gelato. The orange-fleshed sweet potato (*Ipomoea batatas* L.), also known as BSP, is a nutrient-rich local food with a naturally sweet taste. The orange color of sweet potatoes is due to the presence of 7700 IU/100 g of ß-carotene pigment (11). In addition to enhancing color, β-carotene serves as a provitamin A and antioxidant that helps neutralize free radicals. BSP is also a good source of dietary fiber, containing 3.68 g/100 g of soluble fiber. The benefits of consuming fiber are lower blood glucose levels, prolonged satiety, improved digestion, and reduced blood cholesterol levels (12). Additionally, fiber has water-binding properties that prevent the formation of large ice crystals in gelato, thereby improving texture and increasing melting time. The incorporation of BSP paste at an optimal concentration is expected to enhance the physicochemical and hedonic properties of soymilk gelato. The study aimed to evaluate the effect of BSP paste addition on the physical characteristics (overrun and melting time), chemical characteristics (fat content and crude fiber content), and hedonic properties of soymilk gelato.

## Materials and Methods

### *Materials*

The ingredients used are BSP, water, pure soymilk, tapioca flour, sugar, (Carboxymethyl Cellulose) CMC, non-dairy whipping cream, vanilla paste, vinegar, aquadest, 1.25% $H_2SO_4$, 1.25% NaOH, 96% ethanol, filter paper, litmus paper, and 25% HCL.

### *Preparation of Beauregard sweet potato paste*

The preparation of beauregard sweet potato paste is based on previous research with modifications (13). BSP peeled and washed. The sweet potato is cut into small squares with a knife and then steamed for 20 minutes. Steaming can minimize the degradation of water-soluble nutrients compared to boiling method (14). The BSP that has been steamed is added to water in a ratio of 1:1, then mashed with a food processor until a soft texture is obtained.

### *Preparation of soymilk gelato*

The preparation method of soymilk gelato is based on previous research with modifications (12). Pure soymilk is heated to a boil. The temperature of the soymilk was allowed to decrease to 60 °C, and then 5% acetic acid solution was added to as much as 5% of the amount of soymilk. The optimal concentration of acetic acid as a protein coagulant is 5% (15). Coagulation of soy protein into curd occurs for 10 minutes. Whey and curd were separated through a 200-mesh cloth filter. The soymilk curd is blended until it has a creamy texture. The cream is then mixed with soymilk, pandan leaves, sugar, tapioca flour (fat replacer), vanilla paste, and CMC, which are then heated at 80°C until the mixture thickens. The pandan leaves are removed after the mixture thickens because they are only used

as a flavor enhancer. The use of tapioca flour as a fat replacer was based on previous research comparing tapioca, rice, and corn flour, where tapioca flour provided the best texture and melting time (38). The dough is left at room temperature until the temperature is 60°C (cooling down). Nondairy whipping cream is whipped until stiff in a different bowl with a mixer. Nondairy whipped cream that has stiffened is mixed into the bowl containing the dough, which has lowered the temperature. BSP paste was added to the dough according to the treatment, namely 0%, 7.5 %, 15%, 22.5%, and 30% of the total ingredients (w/w), then homogenized with a mixer. The dough enters the aging stage for 4 – 6 hours at 0 – 5°C then it is put into the ice cream maker for 45 minutes. The last step in making soymilk gelato is hardening, where the dough is placed in a freezer at -18°C.

*Parameter analysis*

Crude fiber content was tested through the gravimetric method (12), which is similar in principle to the AOAC method. The modification included using 1.25% $H_2SO_4$ and 1.25% NaOH solutions for sequential digestion, followed by filtration, washing, drying, and incineration to obtain the crude fiber residue. The fat content was analyzed using the weibull-modified soxhlet method, where the modification involved an initial acid hydrolysis step to break fat-protein and fat-carbohydrate bonds, allowing for better fat extraction. The extracted fat was then quantified gravimetrically after solvent removal (16). All physicochemical parameters were tested in quadruplicate to ensure accuracy. Melting time was tested by measuring the time needed for the gelato to melt completely at 25°C using a stopwatch, where the relative humidity generally ranges from 50% to 60% (17). Overrun is calculated by comparing the difference between the weight of the dough and the weight of the gelato with the weight of the dough (18). Hedonic testing was conducted with 25 trained panelists who were briefed on the sensory evaluation criteria for gelato (color, aroma, taste, texture, and overall preference) and used a 4-point rating scale (1 = strongly dislike, 4 = strongly like) (19). Prior to testing, the panelists underwent training to calibrate their assessments.

*Data analysis*

Parametric data were processed with an Analysis of Variance (ANOVA) followed by the Duncan Multiple Range Test with 5% confidence level, while nonparametric data were analyzed using the Kruskal-Wallis test followed by the Mann-Whitney test with 5% confidence level to determine significant differences between treatments. Data analysis was performed using Statistical Product and Service Solutions (SPSS) for Windows 26.0 software.

## Results

The chemical properties of gelato can be evaluated from the crude fiber content and fat content. Based on the ANOVA calculation, the addition of BSP paste with different concentrations significantly affected the chemical properties, which could be seen based on the crude fiber and fat content ($p<0.05$). The crude fiber content of soymilk gelato ranged from 2.13% to 8.25%, while the fat content ranged from 7.88% to 10.42%.

The physical properties of gelato can be evaluated in terms of melting time and overrun. Based on the ANOVA calculation, the addition of BSP paste with different concentrations significantly affected the physical properties, as evidenced by the observed changes in melting time and overrun ($p<0.05$). The melting time of soymilk gelato ranged from 34.96 to 55.26 minutes, while the overrun of soymilk gelato ranged from 29.27% to 19.17%.

The hedonic test results which include color, aroma, taste, texture, and overall preference can be seen in Table 3. Based on Kruskal-Wallis calculations, it can be seen that the addition of BSP paste with different concentrations had a significant ($p<0.05$) effect on the color, aroma, taste, texture, and overall preferences of soymilk gelato.

The hedonic score for gelato color ranged from 2.36 to 3.60, from dislike to strongly like. The hedonic score for gelato aroma ranged from 2.48 to 3.28, which is dislike until like. The hedonic score for gelato taste ranged from 2.20 to 3.20, which is from dislike to like. The hedonic score for gelato texture ranged from 2.56 to 3.20. The hedonic score for overall preference for

gelato ranged from 2.48 to 3.20, which is from dislike to like.

## Discussion

The crude fiber content in Table 1 shows that the higher the concentration of BSP paste added, the higher the crude fiber content produced. This occurred because the BSP contains 3.68 g/100 g of fiber (20). Even though BSP paste was not added, the control gelato (P0) contained 2.13% fiber. This is because the fiber content in the sample is also influenced by other raw materials. Soymilk contains 3 g/100 g of fiber (21). Moreover, the addition of 0.5% CMC (carboxymethyl cellulose) also contributes fiber to gelato. There is no standard fiber content for gelato in SNI 3713:2018 regarding ice cream, so the presence of fiber in gelato is an adds value (22). Based on the 2019 Recommended Dietary Allowances (RDA) data, the daily fiber requirement for children aged 7 - 9 years is 23 g, for men aged 19 - 29 years is 28 g, and for women aged 19 - 29 years is 27 - 32 g (23). One cup (68 g) of soymilk gelato formulation T0 can contribute 1.45 g of fiber, which is equivalent to 4.53% of the daily fiber requirement. On the other hand, the T4 formulation is 5.61 g of fiber, which is equivalent to 17.53% of the daily fiber requirement. The fat content in Table 1 shows that the higher the concentration of BSP paste added, the lower the fat content. This occurred because the fat content in BSP is lower than soymilk. The fat content of BSP in 100 g is 0.42 g, while the fat content in soymilk is 2.50 g/100 g (24). The fat content in gelato is also influenced by another raw material, namely nondairy whipped cream. Non-dairy whipping cream contains 10 g of fat per 38 g serving. The fat content contained in commercial gelato is 4 – 11% (25). The fat content in all gelato formulations is in accordance with these standards. The lowest fat content, measuring 7.88%, was obtained from the gelato formulation T4, while the highest fat content, measuring 10.42%, was obtained from the control gelato (T0). According to the Indonesian Balanced Nutrition Guidelines, fat should account for approximately 25–30% of the total daily caloric intake, which means that for an average 2000 kcal diet, the recommended fat intake is about 55–70 grams per day (26). Assuming a typical serving size of 100 grams for gelato, the fat content in our product (7.88–10.42 grams) is relatively moderate and acceptable as a dessert when consumed in moderation. The melting time in Table 2 shows that the higher the concentration of the BSP paste added, the longer it takes for the gelato to melt completely. This enhanced melting time is primarily due to the increased fiber content from BSP paste, which augments the water-binding capacity of the gelato matrix (27). As a result,

**Table 1.** Chemical Properties of Soymilk Gelato

| Chemical Properties | The Addition of Beauregard Sweet Potato Paste | | | | |
|---|---|---|---|---|---|
| | T0 (0%) | T1 (7.5%) | T2 (15%) | T3 (22.5%) | T4 (30%) |
| Crude Fiber Content | 2,13±0,08$^{a}$ | 4,58±0,09$^{b}$ | 6,73±0,04$^{c}$ | 7,26±0,09$^{d}$ | 8,25±0,09$^{e}$ |
| Fat Content | 10,42±0,09$^{e}$ | 9,22±0,10$^{d}$ | 8,95±0,04$^{c}$ | 8,43±0,10$^{b}$ | 7,88±0,07$^{a}$ |

Data are shown as Mean±Standard Deviation where different superscripts on the bars indicate significant differences between treatments ($p<0.05$).

**Table 2.** Physical Properties of Soymilk Gelato

| Physical Properties | The Addition of Beauregard Sweet Potato Paste | | | | |
|---|---|---|---|---|---|
| | T0 (0%) | T1 (7.5%) | T2 (15%) | T3 (22.5%) | T4 (30%) |
| Melting time | 34,96±0,73$^{a}$ | 39,04±0,70$^{b}$ | 43,14±1,31$^{c}$ | 48,13±0,84$^{d}$ | 55,26±0,72$^{e}$ |
| Overrun | 29,27±0,73$^{e}$ | 27,05±2,25$^{de}$ | 25,93±0,94$^{bc}$ | 23,76±2,16$^{b}$ | 19,17±2,03$^{a}$ |

Data are shown as Mean±Standard Deviation where different superscripts on the bars indicate significant differences between treatments ($p<0.05$).

**Table 3.** Hedonic of Soymilk Gelato

| Parameters | The Addition of Beauregard Sweet Potato Paste | | | | |
|---|---|---|---|---|---|
| | T0 (0%) | T1 (7.5%) | T2 (15%) | T3 (22.5%) | T4 (30%) |
| Color | 2,36 ± 0,70[a] | 2,96 ± 0,73[b] | 3,20 ± 0,71[b] | 3,32 ± 0,56[bc] | 3,60 ± 0,64[c] |
| Aroma | 2,48 ± 0,87[a] | 2,60 ± 0,71[ab] | 2,80 ± 0,76[ab] | 2,96 ± 0,68[bc] | 3,28 ± 0,68[c] |
| Taste | 2,20 ± 0,91[a] | 2,48 ± 0,71[a] | 2,72 ± 0,68[ab] | 3,00 ± 0,87[bc] | 3,20 ± 0,76[c] |
| Texture | 3,20 ± 0,82[a] | 3,16 ± 0,99[a] | 2,84 ± 0,69[ab] | 2,76 ± 0,92[ab] | 2,56 ± 0,76[b] |
| Overall | 2,48 ± 0,58[a] | 2,72 ± 0,68[ab] | 3,08 ± 0,64[bc] | 3,20 ± 0,58[c] | 2,96 ± 0,45[bc] |

Data are shown as Mean±Standard Deviation where different superscripts on the bars indicate significant differences between treatments ($p<0.05$).

the gelato becomes denser and thicker, limiting water migration and delaying melting. Another ingredient that affects melting time is CMC, which further binds water and slows its release from the gel matrix. Moreover, the overrun value influences melting behavior; a higher overrun, indicative of more air bubbles, accelerates melting, whereas a lower overrun contributes to a more stable structure (28). The phenomena that occur during melting include the disruption of the emulsion system and the melting of ice crystals and fat globules. The overrun value in Table 2 shows that increasing the use of BSP in the gelato formulation leads to a decreasing overrun value. This occurred because the fat content in gelato decreases as the fiber content increases. A low fat content inhibits the formation of a three-dimensional structure that traps air during the agitation process, resulting in a low overrun value (29). The overrun value decreases with increasing fiber content because fiber thickens the gelato mixture. Thick and dense gelato dough indicates the tightness of the spaces between the dough particles, making it difficult for air to enter during the agitation process (28). The value of overrun is inversely proportional to melting time. A high overrun indicates a large number of air bubbles in the gelato, resulting in faster melting time. Commercial gelato typically exhibits an overrun range of 15 to 30% (30). In our study, all formulations fell within this range; the T0 formulation had the highest overrun at 29.27%, while the T4 formulation showed the lowest at 19.17%. Based on Table 3, the increase in the concentration of the BSP paste made the panelists prefer the color of the gelato. This is related to the concentration of orange color, which increases with the addition of BSP paste concentration. BSP contains β-carotene pigment, which gives it an orange color (11). The color of the gelato that the panelists disliked was obtained from the control gelato, while the preferred color was gelato with the most addition of BSP paste (T4). This occurred because the panelists prefer orange over white in the control gelato. As well as observed at T1, T2, and T3. The panelists preferred the gelato formulation in T3 compared to T1 and T2 because the intensity of the orange color in T3 was more intense. Color is an important sensory property because it is the first impression of a food product that determines panelist acceptance (13). The results of the hedonic test on aroma showed that the increase in the addition of BSP paste made the gelato's aroma more preferred. This is presumably because the panelists prefer the aroma of BSP to soymilk. The aroma of BSP comes from volatile compounds in the form of hexanal, monoterpenes, and furans, which are formed during steaming (31). The control gelato aroma (T0) was not liked by the panelists. This is apparently due to the unpleasant aroma of soymilk, which the panelists dislike. In addition, the soy curd also creates a sour aroma in the gelato. The sour aroma comes from the vinegar solution used to make curd. The aroma of gelato is also influenced by other ingredients, namely vanilla paste and pandan leaves. Pandan leaves have a strong aroma derived from the compound 2-acetyl-1-pyrroline (32). The hedonic score of gelato taste in Table 3 showed that the increase in the addition of BSP paste made soymilk gelato preferred by the panelists. This occurred because the BSP paste has a sweet taste that the panelists like. Orange fleshed sweet potato has a sweet

taste because it contains high sugar (33). The control gelato (T0) and the gelato formulation 7,5% (T1) were disliked by the panelists. This is presumably due to the dominant sour taste of the curd in the sample. The taste of gelato is also influenced by soymilk, whipped cream, and sugar. The hedonic score of gelato texture showed that all gelato formulations from T0 to T4 were liked by the panelists, likely because the BSP paste contains carbohydrates, that stabilize water-holding capacity and soften the texture (34). However, when used in excessive amounts, BSP paste leads to a reduction in fat content, which normally softens the texture through small and homogeneous fat particles (35), and an increase in fiber content. The higher fiber content makes the gelato thicker and denser, hindering air incorporation and resulting in a lower overrun, which contributes to a gritty texture that panelists find less appealing. Additionally, the presence of a water-binding stabilizer helps inhibit ice crystal formation (36). The highest average panelist preference level for overall gelato was obtained from the T3 formulation, while the lowest was obtained from the T0 formulation. This is apparently because the panelists liked the taste, aroma, and color of gelato T3, while the color, taste, and aroma of gelato P0 were not liked by the panelists. The panelist's preference level for the product is subjective, depending on the panelist's taste. The results in Table 3 show that there was an increase in the overall hedonic score of gelatos from T0 to T3, but a decrease in the gelato formulation P4. This is apparently because gelato formulation P4 has the lowest texture hedonic score. The hedonic overall preference for gelato is determined by the texture, color, aroma, and taste of the gelato (37).

## Conclusion

The addition of BSP paste can increase fiber content, melting time, and hedonicity on color, aroma, and taste, as well as reduce fat content, overrun, and hedonicity on the texture of soymilk gelato. The addition of 30% BSP paste was the best treatment because it produced soymilk gelato that was high in fiber, had a standardized amount of fat, had good melting time and overrun, and had favorable sensory properties.

**Conflict of Interest:** Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

**Authors' Contributions:** SS and VAD contributed to laboratory research for the data production and writing the manuscript. AML and VPB assisted in the data analysis as well as the statistical procedure. BESsupported the English editing of manuscript. NN contributed to setting some laboratory instruments.

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