

Research Article

Physicochemical, Sensory, and Proximate Properties of Jelly Formulated with Black Fungus Mushroom Extract (*Auricularia polytricha*) and Stingless Bee Honey

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ABSTRACT

This study was conducted to develop a jelly using a mixture of black fungus mushroom extract and stingless bee honey. Five formulations of jellies were prepared with different percentage of black fungus mushroom extract [F1(0%); F2(10%); F3(20%); F4(30%) and F5(40%)] with the addition of 1% of stingless bee honey. The jellies were further analysed for their physicochemical properties, sensory attributes and proximate composition. The texture analysis showed a decrease in hardness and gumminess, while springiness, adhesiveness and cohesiveness remain unchanged. Syneresis and colour analysis indicated significant differences between F1 (control) and F2-F4, whereas no significant differences were observed in water activity and pH. Based on the hedonic test, F2 was identified as the best formulation according to the overall acceptability. These findings highlight the potential of black fungus mushrooms extract and stingless bee honey for the development of jelly-products that can be incorporated into beverages for enhancing texture, sensory appeal and functionality.

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1. Introduction

The beverage market has become increasingly competitive due to the continuous introduction of innovative products designed to meet evolving consumer preferences. Beverage manufacturers must ensure that their

products not only satisfy consumers' needs but also align with current market trends, which emphasize appealing flavors, health-promoting properties, and attractive product appearance (Ibrahim *et al.*, 2024). One emerging innovation in the beverage industry is the incorporation of particulate or small ingredients to enhance visual appeal and provide added value to the product. These inclusions may consist of fruit pieces, herbal flakes, agar fragments, jelly particles, nata de coco, boba pearls, and other edible components (Pin *et al.*, 2024). The incorporation of such ingredients can enhance the nutritional profile of beverages while providing unique textural characteristics, mouthfeel, and a pleasant chewing sensation during consumption.

Black fungus mushroom (*Auricularia polytricha*) is an edible fungus widely cultivated in countries such as Korea, China, Russia, and Japan, and is recognized as one of the four major edible mushrooms cultivated worldwide (Pak *et al.*, 2021). It is commonly known by several names, including black fungus, jelly ear, wood ear, and cloud ear fungus (Bao *et al.*, 2016). In Malaysia, it is often referred to as black jelly mushroom or black tree ear due to its dark coloration and ear-like morphology. This mushroom is characterized by its jelly-like elastic texture and distinctive crispness after cooking (Mau, 2001). In addition to its culinary applications, black fungus mushroom has been reported to exhibit various bioactive properties, including anti-diabetic, anti-hypertensive, anti-inflammatory, antimicrobial, and anticoagulant activities, which contribute to its widespread use in traditional Chinese medicine (Pak *et al.*, 2021). Furthermore, its consumption has been associated with cholesterol-lowering effects. Nutritionally, black fungus mushrooms contain relatively high levels of protein and dietary fiber compared with other dried mushrooms within the *Auricularia* family. It is also a valuable source of essential minerals, including calcium, iron, magnesium, manganese, nickel, and zinc, which are important for maintaining human health (Shin *et al.*, 2007).

Despite its recognized nutritional and functional benefits, the utilization of black fungus mushroom in the development of innovative food and beverage products remains relatively limited. Expanding its application presents considerable market potential, particularly through the development of jelly-based products enriched with stingless bee honey. This combination is attractive due to its simple formulation, broad consumer appeal, and the high antioxidant content of both ingredients, which may enhance the functional properties of the final product. In jelly production, ingredient composition plays a crucial role in determining the textural characteristics and overall consumer acceptability of the product. However, studies investigating jelly formulations incorporating black fungus mushroom extract and stingless bee honey remain scarce. Therefore, this study aims to develop and evaluate jelly formulations containing black fungus mushroom extract and stingless bee honey.

2. Materials and Methods

2.1 Raw Materials

Fresh black fungus mushrooms (*Auricularia polytricha*) were purchased from Cendawan Cerah Private Limited Company and brought to the laboratory in a refrigerated container. The mushrooms' fruiting bodies were thoroughly washed to remove any surface residues. The cleaned mushrooms were then dried using a cabinet dryer at 90 °C for 120 min. After drying, the mushrooms were ground into powder. Other ingredients used in the development of the jelly, including honey, gelatin, and citric acid, were purchased from a local supermarket.

2.2 Preparation of black fungus mushroom extract

The black fungus mushroom extract was prepared according to the procedures described by Khalil & Lukasiwicz (2024), with slight modifications. Briefly, 10 g of black fungus mushroom powder was mixed with 500 mL of water and heated at 90 °C for 5 h. After extraction, the mixture was centrifuged at 9000 rpm for 10 min using a high-speed centrifuge, and the supernatant was collected.

2.3 Development of the mixture of black fungus mushroom extract with stingless bee's honey jelly formulation

The preparation of jelly followed the procedure described by Kaewpetch *et al.* (2024), with some modifications. The ingredients consisted of black fungus mushroom extract (0-40%), stingless bee honey (1%), sugar (10%), gelatin (6%), citric acid (0.3%) and water (42 – 82%) as shown in Table 1. Gelatin was first soaked in warm water until fully swollen. Then, the gelatin was heated at 70 °C until completely dissolved and thoroughly mixed. The fully dissolved gelatin was subsequently filtered and cooled to 65 °C. Next, Stingless bee honey was added and mixed to the gelatin solution until blended to a homogeneous solution. The gelatin mixture was then combined with black fungus mushroom extract according to the specified formulation. Citric acid was added at the end of the cooking process and stirred until evenly mixed. The liquid jelly mixture was poured into the prepared molds using a pouring funnel. The jelly was then allowed to set in a refrigerator at 4 °C. The final product obtained was in jelly form and called Black Fungus Mushroom Extract–Stingless Bee Honey mixture jelly (BFME–SBH jelly). Processes involved in the development of black fungus mushroom extract and stingless bee honey jelly are shown in Figure 1.

Table 1. Development of jellies from black fungus mushroom extracts with stingless bee's honey

Formulation	Black fungus mushroom extract	Stingless bee honey	Gelatin	Sugar	Citric acid	Water
F1 (Control)	0	1	6	10	0.3	82.70
F2	10	1	6	10	0.3	72.70
F3	20	1	6	10	0.3	62.70
F4	30	1	6	10	0.3	52.70
F5	40	1	6	10	0.3	42.70

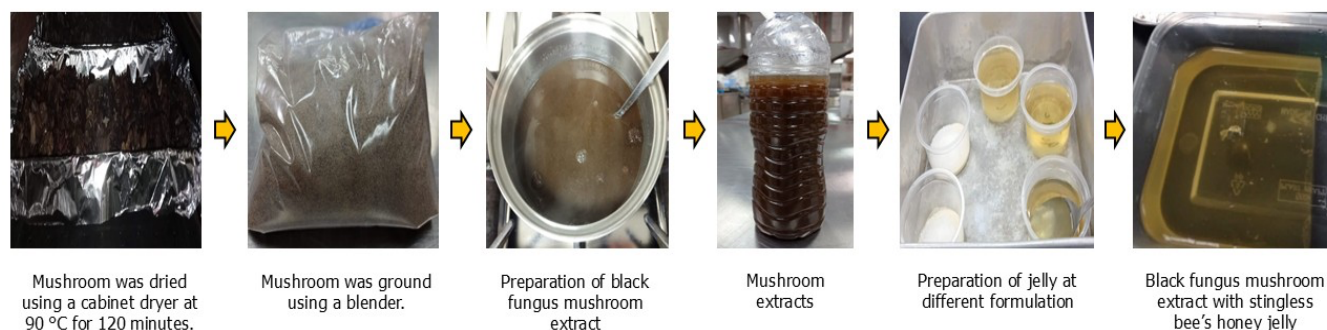


Figure 1. Procedures involved in the development of black fungus mushroom extract and stingless bee honey jelly.

2.5 Characterizations

2.5.1 Texture Profile Analysis (TPA)

The texture of BFME–SBH jelly was determined using a texture analyzer (Texture Technologies Corp., Stable Micro Systems Ltd., U.K., Model TA. XT-2i) with slight modifications to the method described by Dhabitah *et al.*, (2025). The instrument was fitted with a 5 kg (50 N) load cell and operated through XT.RA Dimension software (Texture Technologies Corp., Scarsdale, NY), which recorded and analyzed for hardness, cohesiveness, adhesiveness, springiness, gumminess, chewiness, and resilience. The BFME–SBH jelly samples were cut into cubes (1 cm × 1 cm × 1 cm), with nine replicates prepared for analysis. The instrument parameters were set to a test speed of 1.0 mm/s and a post-test speed of 1.0 mm/s, with 50% deformation using a 50 mm-diameter. The texture profile values were calculated as the mean of three measurements obtained from the nine sample replicates.

2.5.2 Determination of Water Activity

Water activity was measured using an AquaLab Water Activity Meter. About 3 g of BFME–SBH jelly was placed in a plastic container and inserted into the instrument chamber. The water activity (a_w) value was then recorded (Suhaili *et al.*, 2021).

2.5.3 Determination of Syneresis

The syneresis of the BFME–SBH jelly was determined on the second day at refrigerated and room temperature. Each jelly sample was prepared in a small mold container, weighed, and stored in the refrigerator overnight. The samples were then taken out, and tissue paper was used to absorb the liquid released from the jelly. The jelly was weighed again to determine the weight loss. The uniformity of each sample was considered to ensure the accuracy of the analysis. The percentage of syneresis was calculated using the following equation:

$$\text{Syneresis (\%)} = \frac{\text{Weight of separated liquid (g)}}{\text{Weight of jelly (g)}} \times 100 \quad (1)$$

2.5.4 pH Measurement

The pH values of the jelly samples were measured using a tabletop pH meter (Mettler-Toledo GmbH, Giessen, Germany). Prior to analysis, the jelly samples were homogenized thoroughly to ensure uniformity and consistent pH determination. The pH meter was calibrated with standard buffer solutions at pH 4.0 and pH 7.0 before use. Measurements were performed in triplicate for each sample, and the results were expressed as mean values.

2.5.5 Color Measurement

Color measurement was carried out following the method described by Dhabitah *et al.*, (2025) using a chroma meter (CR-400, Konica Minolta, Japan). The chroma meter operated based on the CIE Lab* (CIELAB) color system, which directly measures the color coordinates L^* , a^* , and b^* . The parameter L^* represents lightness (ranging from black to white), while a^* indicates redness (positive values) or greenness (negative values), and b^* represents yellowness (positive values) or blueness (negative values). The BFME–SBH jelly samples were cut into cubes measuring 5 cm × 5 cm × 1 cm prior to color measurement.

2.5.6 Sensory Evaluation

The sensory evaluation of BFME–SBH jelly was conducted using a nine-point hedonic scale to assess consumer acceptance of the products. A total of 40 untrained panelists, comprising both male and female participants, were recruited for the evaluation (Kaewpetch *et al.*, 2024). The jelly samples were prepared in uniform cubes measuring 2 cm × 2 cm × 2 cm and served at room temperature. Each sample was assigned a randomly generated three-digit code to prevent identification bias. The serving order of the samples was randomized among panelists to minimize potential order and carry-over effects. Panelists were provided with drinking water and instructed to rinse their mouths between samples to reduce sensory fatigue and flavor carry-over. The panelists evaluated the samples based on color, aroma, taste, texture, and overall acceptability using a nine-point hedonic scale, where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely. The sensory evaluation results were subsequently analyzed to determine the most acceptable formulation of BFME–SBH jelly.

2.5.7 Proximate Analysis

The proximate composition (moisture, ash, protein, fibre, fat, and carbohydrate) of the BFME–SBH jelly was determined according to the Official Methods of Analysis of AOAC INTERNATIONAL (AOAC, 2023). All samples were expressed on a wet weight basis. Protein content was determined using the Kjeltac instrument (FOSS Kjeltac 2300, Denmark), with a protein conversion factor of 4.38 (Rivoldiantoe *et al.*, 2025). The total carbohydrate content was calculated according to Equation 2:

$$\text{Total carbohydrate (\%)} = 100 - \text{Moisture (\%)} - \text{Ash (\%)} - \text{Protein (\%)} - \text{Fibre (\%)} - \text{Fat (\%)} \quad (2)$$

2.6 Statistical Analysis

All data were expressed as mean $\pm$ standard deviation. Each value represents the mean of three replicates. Statistical analysis was performed using one-way analysis of variance (ANOVA), followed by Duncan's multiple range test to determine significant differences among means at $p < 0.05$ using SPSS software (version 17 for Windows XP, SPSS Inc.). The comparison of nutritional composition between the control and the best formulation was analyzed using an independent t-test.

3. Results and Discussion

3.1 Texture Profile Analysis (TPA)

Texture is considered one of the most important attributes influencing consumers satisfaction. As shown in Table 2, hardness and gumminess values of BFME–SBH jelly products decreased significantly from F2 to F5 ($P \leq 0.05$), while springiness, adhesiveness and cohesiveness showed no significant differences. Hardness is defined as the force required to achieve a specific deformation. It is also correlated with the strength of gel structure under compression (Anuar *et al.*, 2022). In sensory analysis, it corresponds to the force needed to compress a food sample between the back teeth (molars) during the first bite. Variations in jelly hardness could be related to the internal degradation or formation of pectin, which under the influence of temperature and pH, undergo depolymerization (Morris *et al.*, 2010).

Table 2. Texture properties of jellies from black fungus mushroom extracts with stingless bee's honey

Texture Profile	F1 (0%)	F2 (10%)	F3 (20%)	F4 (30%)	F5 (40%)
Hardness (N)	236.1 $\pm$ 7.4 ^b	243.6 $\pm$ 10.3 ^a	231.0 $\pm$ 12.2 ^b	219.9 $\pm$ 7.6 ^c	200.7 $\pm$ 21.3 ^d
Gumminess (N)	219.1 $\pm$ 6.6 ^b	224.9 $\pm$ 10.5 ^a	212.5 $\pm$ 13.0 ^c	201.3 $\pm$ 13.6 ^d	188.2 $\pm$ 20.1 ^e
Springiness	2.0 $\pm$ 0.1 ^a	1.9 $\pm$ 0.0 ^a	1.9 $\pm$ 0.1 ^a	1.9 $\pm$ 0.0 ^a	1.9 $\pm$ 0.1 ^a
Adhesiveness	-0.3 $\pm$ 0.1 ^a	-0.6 $\pm$ 0.5 ^a	-0.4 $\pm$ 0.5 ^a	-0.7 $\pm$ 0.0 ^a	-0.5 $\pm$ 0.4 ^a
Cohesiveness	0.9 $\pm$ 0.0 ^a	0.9 $\pm$ 0.1 ^a	0.9 $\pm$ 0.0 ^a	0.9 $\pm$ 0.0 ^a	0.9 $\pm$ 0.0 ^a

^{a,b} Different superscripts in the same row denote significant difference, $p < 0.05$.

In this study, the bioactive compounds present in mushroom extract, particularly polysaccharides, may interact with gelatin and influence the formation of the gel network, thereby affecting the textural properties of the jelly such as hardness and gumminess. The highest hardness value was observed at 10% mushroom extract, indicating the formation of a stable and well-developed gel network. However, as the concentration of mushroom extract increased, the firmness of the jelly decreased. This reduction may be attributed to the higher amount of polysaccharide molecules present in the formulation, which can interfere with gelatin gel formation. Excess polysaccharides may disrupt the protein network by limiting effective protein–polysaccharide interactions, thereby weakening the gelatin structure and producing a softer gel (Boonjing & Ruttarattanamongkol, 2020). Gumminess represents the energy required to disintegrate a semi-solid food product into a state ready for swallowing (Kreungngern & Chaikham, 2016). A similar decreasing trend was observed for gumminess in BFME–SBH jelly as the mushroom extract concentration increased. The reduction in gumminess observed in BFME–SBH jelly suggests that polysaccharides from the mushroom extract disrupted the internal bonding structure of the gelatin matrix, weakening the gel network and reducing structural integrity (Kreungngern & Chaikham, 2016).

No significant differences ($p > 0.05$) were observed in the springiness, adhesiveness, and cohesiveness of the jelly among the different formulations, indicating that the incorporation of mushroom extract did not significantly affect the elastic recovery and surface stickiness of the gel system. Springiness is related to the height that the food recovers during the time that elapses between the end of the first bite and start of the second bite. It reflects the ability of a gel to return to its original shape after compression.

Adhesiveness represents the work required to pull the compressive probe away from the sample, while cohesiveness represents the strength of the internal bonds making up the body of the product where the lower the cohesiveness of a material, the more brittle it will be (Kreungngern & Chaikham, 2016). Similar values obtained suggest that the gelatin network remained relatively stable despite the addition of mushroom extract. This may be attributed to the constant jelly percentage. Although the mushroom extract contains polysaccharides, their presence may not have been sufficient to significantly modify the elastic properties of the gelatin matrix. As a result, the overall structural recovery and surface adhesion of the jelly remained relatively unchanged among the samples.

3.2 Physicochemical Properties of BFME–SBH mixture jelly

3.2.1 Water activity

The water activity (a_w) of the BFME–SBH jelly ranged from 0.85 to 0.86, with no significant differences ($p > 0.05$) observed among the formulations. This suggests that variations in the concentration of black fungus mushroom extract did not significantly influence the availability of free water in the jelly system. The similar a_w values observed across samples may be attributed to the consistent formulation of other key ingredients, particularly gelatin and stingless bee honey, which play a dominant role in binding water within the gel matrix. Furthermore, both gelatin and mushroom-derived polysaccharides possess water-binding properties that contribute to the stabilization of water molecules within the gel network. Polysaccharides interact with water through hydrogen bonding, thereby limiting water mobility and maintaining relatively stable water activity in gel-based systems (Pascui *et al.*, 2012). As a result, the incorporation of different concentrations of mushroom extract did not significantly alter the overall water distribution in the jelly product.

The a_w values obtained (0.85–0.86) indicate that the jelly can be classified as an intermediate-moisture food, in which microbial growth may still occur but at a slower rate compared to high-moisture foods (Boonjing & Ruttarattanamongkol, 2020). However, the a_w values are slightly lower as compared to the standard level for drinking jelly or fruit jelly-based products which range from 0.92 to 0.99 (Charoenphun *et al.* 2025). This might be due to the gelatin used as a gelling agent having a lower binding capacity than sodium alginate, carrageenan, and agar (Jiménez-Escrig *et al.*, 2000).

3.2.2 Syneresis analysis

Syneresis refers to the release of liquid from a gel network as a result of structural contraction or instability within the gel matrix. It is commonly used as an indicator of the water-holding capacity and stability of gel-based food products (Nguyen *et al.*, 2022). Syneresis values were significantly lower in F2–F5 compared with the control, indicating improved water-holding capacity after incorporation of black fungus mushroom extract. The low syneresis values observed suggest that the jelly possessed high water-holding capacity, primarily due to the presence of gelatin which plays a major role in forming a stable three-dimensional network capable of trapping water within the gel structure (Nguyen *et al.*, 2022). Besides that, polysaccharides present in the mushroom extract may have contributed to water retention within the gel system due to their hydrophilic nature and ability to bind water molecules through hydrogen bonding. These properties may help maintain the stability of the gel matrix and prevent excessive water release.

3.2.3 Determination of pH

Table 3 presents the results of water activity, syneresis, pH, and color of the BFME–SBH jelly. Overall, the pH values of the jelly samples ranged from 5.5 to 5.8. According to Charoenphun *et al.* (2025), a pH below 5 is generally more effective for preserving jelly products because it inhibits the growth of common spoilage microorganisms. When the pH increases, the risk of microbial growth also increases, which may lead to a shorter shelf life of drinking jelly.

3.2.4 Color measurement

In food quality analysis, color is a critical sensory attribute because it strongly influences consumer perception and acceptability. Table 3 shows that the lightness (L^*) values of the BFME–SBH jelly ranged from 19.2 to 33.4. Among the formulations, F1 recorded the highest L^* value (33.4), indicating a lighter

appearance, while F2, F3, F4, and F5 showed significantly lower L^* values ranging from 25.3 to 19.2. However, no significant differences ($p > 0.05$) were observed among F2, F3, F4, and F5. The L^* value represents the lightness of a sample, where higher values indicate a lighter color and lower values indicate a darker appearance (Kaewpetch *et al.*, 2024).

The higher L^* value observed in F1 may be attributed to the absence of black jelly mushroom extract, resulting in a lighter-colored jelly. However, the L^* value for F1 is still considered relatively low due to the presence of gelatin and stingless bee honey in the formulation. This is because honey and gelatin participate in browning reactions through the Maillard reaction and caramelization, which occur when sugars and amino acids are heated together at high temperatures (Kaewpetch *et al.*, 2024). The addition of mushroom extract in F2 to F5 contributed to a darker color in the jelly due to the natural dark pigments present in the mushroom, as well as the browning reactions involving honey and gelatin. Black fungus mushroom naturally possesses dark brown to black pigments that can significantly influence the color of food products when incorporated into formulations. The absence of significant differences between F2 to F5 suggests that once the mushroom extract was incorporated into the jelly formulation, further increases in extract concentration did not substantially alter the lightness of the product. This may indicate that the color intensity of the mushroom extract had already reached a saturation point in the jelly matrix, resulting in relatively stable L^* values among these formulations.

When comparing the a^* values of the five jelly formulations, F1 (0.2) had the lowest value, indicating that it exhibited the least redness among all samples. As the concentration of mushroom extract increased (F2–F5), the jellies became more reddish-brown in color, which may be associated with browning reactions occurring during processing (Kaewpetch *et al.*, 2024). As for the b^* value, F1 (12.2) and F2 (12.0) had the highest values and were not significantly different, indicating that these jellies exhibited similar yellow tones. However, as the concentration of mushroom extract increased, the yellowish color of the jelly showed a significant decrease ($p < 0.05$). This decrease may be attributed to the addition of mushroom extract, which has a naturally dark color, as well as the Maillard reaction between gelatin and honey during jelly preparation.

Table 3. Physicochemical properties of jellies from black fungus mushroom extracts with stingless bee honey

Properties	F1	F2	F3	F4	F5
Water activity (%)	0.86 ± 0.01 ^a	0.86 ± 0.01 ^a	0.86 ± 0.00 ^a	0.85 ± 0.00 ^a	0.86 ± 0.00 ^a
Syneresis	0.3 ± 0.0 ^a	0.2 ± 0.0 ^b	0.2 ± 0.0 ^b	0.2 ± 0.0 ^b	0.2 ± 0.0 ^b
pH	5.5 ± 0.1 ^a	5.5 ± 0.2 ^a	5.8 ± 0.0 ^a	5.6 ± 0.0 ^a	5.6 ± 0.1 ^a
Color					
L^*	33.4 ± 5.1 ^a	25.3 ± 1.0 ^b	21.3 ± 2.1 ^b	19.4 ± 0.5 ^b	19.2 ± 0.9 ^b
a^*	0.2 ± 0.1 ^c	2.1 ± 0.1 ^b	2.4 ± 0.2 ^b	3.1 ± 0.3 ^a	3.2 ± 0.2 ^a
b^*	12.2 ± 1.4 ^a	12.0 ± 0.4 ^a	10.0 ± 0.5 ^b	8.6 ± 1.0 ^c	6.9 ± 0.8 ^d

All values are means of triplicate determinations ± SD.

^{a,b} Different superscripts in the same row denote significant difference, $p < 0.05$.

3.3 Sensory evaluation

In this sensory evaluation, four formulations were evaluated based on five attributes. The attributes tested and evaluated are color, aroma, texture, taste and overall acceptance of the jelly produced.

3.3.1 Color attribute

Color is the first attribute perceived by consumers before they taste or smell food. It strongly influences the initial impression and expectations of a product. An attractive color can increase visual appeal and appetite, while an unusual or dull color may lead consumers to perceive the product as spoiled or of low quality (Motoki *et al.*, 2023). The color scores of all jelly samples ranged from 5.6 to 6.9 (Table 5), which falls between "dislike slightly," "like slightly," and "like moderately." It was found that there was a significant

difference ($p < 0.05$) in the acceptance of color attributes between the control formulation (F1) and the other formulations (F2–F5). However, the formulations with the addition of mushroom extract did not show a significant difference in color ($p > 0.05$). Physically, the liquid component of black fungus mushroom extract exhibited a slightly darker color (Ibrahim *et al.*, 2024), which may have influenced the appearance and overall acceptability among the panelists.

3.3.2 Aroma attribute

Aroma refers to the smell or odor released from food, which is detected by the olfactory receptors in the nose. Significant differences ($P < 0.05$) were observed in the aroma acceptability between the jelly formulation without mushroom extract (F1) and those containing mushroom extract (F2–F5). The aroma ratings for the black jelly drinks ranged from 5.3 to 5.9, corresponding to preferences between “dislike slightly” and “like slightly.” This suggests that the initial formulation (F1) may have lacked aromatic intensity, possibly due to lower honey content or a weaker release of volatile compounds from the mushroom extract (Ibrahim *et al.*, 2024). The addition of mushroom extract in the jelly formulations (F2–F5) may have helped balance the aroma acceptability of the jellies.

3.3.3 Texture attribute

Texture refers to the physical characteristics of food perceived through touch and mouthfeel, such as hardness, softness, chewiness, smoothness, or gel strength (Ibrahim *et al.*, 2024). Texture influences the eating quality and comfort during consumption. Texture scores were lowest for F1 (5.9 ± 2.1), while F2–F5 scored ranging from 6.2–6.5 with no significant differences among them. This indicates that F1 may have had a firmer or less cohesive jelly texture, potentially due to insufficient gelation or uneven hydration of ingredients. In contrast, the higher ratings for F2–F5 suggest that texture improved with the addition of mushroom extracts in the formulation, resulting in a smooth, consistent, and palatable jelly.

3.3.4 Taste attribute

Taste is one of the most critical attributes in sensory evaluation because it directly affects consumer satisfaction. The taste scores also reflected this trend, with F1 being lower than the other formulations. This indicates that the original formulation (F1) may have been less balanced in flavor, which is consistent with the gradual increase in mushroom extract. These results are inconsistent with the findings by Ibrahim *et al.* (2024), who noted that most panelists expressed a dislike for black jelly drinks sweetened with honey.

3.3.5 Overall acceptability

Significant differences ($P < 0.05$) were also observed in the overall acceptability between the jelly formulation without mushroom extract (F1) and those containing mushroom extract (F2–F5). The overall acceptability scores ranged from 5.7 to 6.6, reflecting consumer preferences between “like slightly” and “like moderately”. No significant differences were observed among formulations F2–F5, indicating that increasing the concentration of mushroom extract beyond the level used in F2 did not significantly enhance the sensory acceptability of the jelly.

Table 4. Sensory evaluation of jellies from black fungus mushroom extracts with stingless bee’s honey

Attribute	F1	F2	F3	F4	F5
Color	5.6 ± 2.2^b	6.1 ± 1.9^a	6.4 ± 1.6^a	6.7 ± 1.2^a	6.9 ± 2.1^a
Aroma	5.3 ± 1.5^b	5.8 ± 1.3^a	5.8 ± 1.7^a	5.9 ± 1.6^a	5.9 ± 1.6^a
Texture	5.9 ± 2.1^b	6.2 ± 1.6^a	6.3 ± 2.0^a	6.3 ± 1.9^a	6.5 ± 1.6^a
Taste	5.6 ± 2.2^b	6.1 ± 1.6^a	6.0 ± 1.9^a	6.6 ± 1.8^a	6.6 ± 1.4^a
Overall Acceptability	5.7 ± 1.6^b	6.4 ± 1.4^a	6.5 ± 1.1^a	6.5 ± 1.6^a	6.6 ± 1.1^a

All values are means of triplicate determinations $\pm$ SD.

^{a,b} Different superscripts in the same row denote significant difference, $p < 0.05$.

3.4 Proximate analysis

The proximate composition of the best formulation of BFME–SBH jelly with the control formulation is described in Table 5. The moisture content of F1 was 82.0%, while F2 recorded a slightly lower value of 81.7%. The small difference suggests that the incorporation of mushroom extract did not significantly affect the water content of the jelly. However, this value is relatively high compared to other jelly products (Amertaningtyas *et al.*, 2025; Pin *et al.*, 2024). This may be attributed to the ingredients used in the jelly preparation, such as honey, proteins, and polysaccharides, which can bind water molecules through their hydroxyl groups, thereby enhancing water retention in the product (Haroune *et al.*, 2025). The ash content increased from 0.1% in F1 to 0.2% in F2. Ash represents the total mineral content present in food. The ash content reported in the present study is considered low compared to that of other jelly products (Amertaningtyas *et al.*, 2025; Pin *et al.*, 2024). F2 showed a slightly higher protein content (6.5%) compared with F1 (6.3%). This increase may be related to the naturally present protein in mushrooms, as mushrooms contain moderate amounts of protein and essential amino acids that can improve the nutritional value of food products (Ibrahim *et al.*, 2024; Wang *et al.*, 2014). Both formulations recorded the same fat content of 0.3%, indicating that the addition of mushroom extract did not significantly influence the fat level of the jelly. This is expected because mushrooms generally have a very low-fat content, making them suitable for developing low-fat food products (Kadnikova *et al.*, 2015; Wang *et al.*, 2014). The crude fiber content increased slightly from 0.9% in F1 to 1.0% in F2. This increase may be due to the fiber components present in mushrooms, including water soluble polysaccharides such as chitin and glucans. This suggests that incorporating mushroom extract did not affect the nutritional value of the jelly.

Table 5. Proximate Compositions between the best formulation and the control formulation

Analysis	Control (%)	Best Formulation, F2 (%)
Moisture	82.0 ± 0.5 ^a	81.7 ± 0.9 ^a
Ash	0.1 ± 0.1 ^a	0.2 ± 0.1 ^a
Protein	6.3 ± 0.4 ^a	6.5 ± 0.1 ^a
Fat	0.3 ± 0.0 ^a	0.3 ± 0.0 ^a
Crude Fiber	0.9 ± 0.2 ^a	1.0 ± 0.3 ^a
Carbohydrate	10.4 ± 0.7 ^a	10.4 ± 0.8 ^a

All values are means of triplicate determinations ± SD.

^{a,b} Different superscripts in the same row denote significant difference, $p < 0.05$.

4. Conclusion

The study successfully developed a BFME–SBH jelly with improved nutritional, physicochemical, and sensory characteristics. The best formulation (F2) was selected based on sensory evaluation, showing the highest scores in color, aroma, taste, texture, and overall acceptability. The texture profile analysis indicated that F2 had low hardness, pleasant mouthfeel, which aligned with panelists' preferences. Physicochemical analysis revealed that F2 maintained stable water activity and pH, with good color appearance. Proximate analysis indicated that F2 possessed a nutritional profile comparable to the control formulation. Overall, the study demonstrated that incorporating black fungus mushroom extract and stingless bee honey produced a jelly that is nutritionally enriched, functionally beneficial, and sensorially appealing. The findings suggest that this product has potential for commercialization as a functional food, providing consumers with a healthy and palatable alternative to conventional jellies.

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