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Assessment of Physicochemical and Sensory Attributes of Sponge Cake Enriched with Oyster Mushroom Powder

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ABSTRACT

Background: Due to extensive popularity of cake across diverse societal groups, careful consideration of its formulation is essential for creating a health-oriented product. In this context, mushrooms are a prevalent dietary source in Asian countries and are rich in nutrients. **Methods:** This study investigates the effect of replacing wheat flour with oyster mushroom powder with respect to physicochemical characteristics and sensory qualities of developed sponge cake, highlighting the improvement of its nutritional value. Sponge cakes were prepared by replacing wheat flour with oyster mushroom powder at different levels of concentration *i.e.* F_1 = 4% oyster mushroom powder; F_2 = 8% oyster mushroom powder; F_3 = 12% oyster mushroom powder and evaluated against F_0 = control (0% oyster mushroom powder). All the samples were evaluated for their proximate compositions, color metrics and sensory attributes. **Result:** With the increasing concentration of oyster mushroom powder in the sponge cake formulation, the levels of moisture, ash, protein, fat and fiber considerably ($p \leq 0.05$) augmented, whereas the carbohydrate content significantly ($p \leq 0.05$) declined. Consequently, the protein content in the F_3 sample was increased in comparison to the other formulations. With regard to physical characteristics, the L* index diminished as the mushroom percentage increased, whereas a* and b* color indices exhibited an increase ($p \leq 0.05$) with higher mushroom incorporation level. During sensory evaluation, sponge cake with 12% (F_3) mushroom powder received the top ratings for all the sensory qualities. The current study indicated that the addition of oyster mushroom powder for partial substitution of wheat flour in sponge cake enhanced the levels of protein, fiber and ash while reducing its carbohydrate content.

Key words: Oyster mushroom powder, Proximate composition, Sensory attributes, Sponge cake.

INTRODUCTION

Oyster mushroom (*Pleurotus oystreatus*) is an edible mushroom that belongs to the family Pleurotaceae (Randive, 2012). The Oyster mushroom (*Pleurotus oystreatus*) is an edible fungus known for its exceptional aroma and flavor. Pleurotus spp. is rich sources of proteins, carbohydrates, minerals and vitamins. Mushroom contains digestible proteins (10%-40%), carbohydrates (3%-21%), dietary fiber (3%-35%), on dry weight basis which is higher and is of superior quality than those of vegetables and fruits (Mallavadhani *et al*., 2006). The protein content of the fresh mushroom (Agaricus bisporus) is 2-3% while it varies from 32 to 42% on dry weight basis (Mankar *et al*., 2026).

Mushrooms serve as an exceptional food source to mitigate malnutrition in developing nations, attributed to its flavor, texture, nutritional content and high yield per unit area (Eswaran and Ramabadran, 2000). Mushrooms are regarded as a superfood because of their significant nutritional content and medicinal properties (Anusha *et al*., 2023). Incorporating oyster mushrooms into cake preparation may enhance nutritional quality of the final product by enhancing protein, fat, ash and fiber content while reducing sugar content (Al-Zamani *et al*., 2022). Mushrooms can be desiccated and processed into powder, which is subsequently utilized for fortification in baked products such as bread, biscuit and cake.

Despite their high protein, fiber, vitamin and mineral content, oyster mushrooms (*Pleurotus ostreatus*) are underutilized in cakes as compared to breads and biscuits. Limited studies have examined the impact of varying amounts of mushroom powder on the physicochemical and sensory characteristics of sponge cakes. Hence, the

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present study examines the value addition of Oyster mushroom powder to wheat flour in order to improve the nutritive value of cake while maintaining the taste and texture. The objective is to create available, health-oriented bakery item tailored for diabetic and cholesterol-aware consumers, while also encouraging the commercial utilization of locally sourced, underexplored oyster mushrooms within the baking industry.

MATERIALS AND METHODS

The experiment was conducted during the period from July to November 2025 in the research laboratory of the Department of Food Engineering, Jashore University of Science and Technology, Bangladesh.

Collection of materials

The oyster mushroom powder was procured from a local market in Savar, Dhaka, Bangladesh. Wheat flour, sugar, baking powder, soybean oil, vanillin, milk, eggs, salt and additional materials were procured from the local market in Jashore, Bangladesh. The required chemicals and reagents were of analytical grade with highest purity (Sigma-Aldrich, USA and Merck, Germany) and all analytical procedures were performed at laboratory of the Department of Food Engineering, Jashore University of Science and Technology.

Development of mushroom sponge cake

Multiple experiments were conducted to prepare the mushroom Sponge cake. Sponge cake was prepared by replacing wheat flour with oyster mushroom powder in three different formulations and tested against the control sample *i.e.* F_0= 0% of oyster mushroom powder, as presented in Table 1.

Oyster mushroom sponge cake was processed through exercising the reference method given by Al-Zamani *et al*. (2022), however, with certain modifications to suit the objectives of the present study. The oil and sugar were first combined till light and airy using a “Vision hand mixer” (model HM 430). Egg white and milk powder were incorporated while mixing continued for approximately 40 minutes. Subsequently, uniform dough was achieved following comprehensive mixing with water. The batter was positioned in a mold and thereafter baked at 175°C for 25 to 30 minutes. The cakes were chilled in a sanitary manner and sealed in impermeable polythene, maintained at room temperature until required for sensory evaluation and other analyses (Wakchaure, 2011). Wheat flour (white) cake samples were designated as the control group. This procedure was derived from the formulation outlined by Al-zamani *et al*. (2022) with certain modifications.

Evaluation of oyster mushroom sponge cake

Physicochemical properties

a) Proximate analysis of oyster mushrooms and mushroom sponge cake

The moisture, protein, fat, ash and fiber contents of mushroom samples were quantified in triplicate following AOAC (Association of Official Analytical Chemists) protocols. The moisture content was determined through oven drying at 105°C until a consistent weight was achieved (AOAC, 2000). The crude protein content was determined using the Kjeldahl method (6.25×N). The total lipid was extracted utilizing the AOAC (2000) method with the Soxhlet device. Ash was quantified gravimetrically in a muffle furnace by heating at 550°C until a consistent weight was achieved (AOAC, 2000). Carbohydrate and energy levels were assessed utilizing the differential and multiplicative methods.

b) Color of oyster mushroom cake

The color values of the sponge cake were assessed using a Precision Colorimeter (BCM-110, manufactured in China). The equipment was calibrated using traditional white and black ceramic tiles. The color parameters L*, a* and b* were quantified. L*, a metric assessing the luminosity of food colors, ranges from black (value 0) to white (value 100). A negative a* value indicates the color green, whereas a positive value signifies the color red-purple. A positive value for b* signifies the color yellow, whereas a negative value indicates the color blue.

Sensory attributes of oyster mushroom cake

The sensory acceptability of sponge cake was assessed using a 9-point hedonic scale. Thirty-five untrained judges, comprising 17 females and 18 males aged 20-30 years, were recruited from the staff and students of the Food Engineering department to assess the appearance, aroma, flavor, texture and overall acceptability of the cakes using a 9-point hedonic scale (1 = extremely dislike, 5 = neutral, 9 = extremely like). Each panelist assessed four random samples. Samples were positioned on white

Table 1: Development of mushroom sponge cake.

Items	F_0	F_1	F_2	F_3
Mushroom powder (g)	0	4	8	12
Wheat flour (g)	100	96	92	88
Milk powder (g)	8	8	8	8
Egg (Pcs)	2	2	2	2
Sugar (g)	70	70	70	70
Sodium bicarbonate (mg)	30	30	30	30
Oil (ml)	20	20	20	20
Vanilla extract (ml)	0.75	0.75	0.75	0.75

plates and designated with arbitrary 3-digit numbers. Panelists assessed the samples in a designated testing area and were directed to rinse their mouth with water between samples to reduce any remaining influence.

Statistical analysis

The experimental data for all measured characters were subjected to statistical analysis for clarity. Each experiment was performed in triplicate (n = 3) and the findings were shown as mean±SD. ANOVA (One-way analysis of variance) and Tukey's test (significant at $p \leq 0.05$) were conducted using SPSS version 25.0 software (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Proximate composition oyster mushroom powder

The result of proximate analysis of oyster mushrooms is presented in Table 2. Oyster mushroom exhibited a proximate composition of 4.89% moisture, 1.28% ash, 17.93% protein, 3.58% fat, 21.44% fiber, 50.88% carbohydrate, with an energy value of 307.46 Kcal/100 gm.

Physicochemical properties of oyster mushroom developed sponge cake Proximate composition oyster mushroom developed sponge cake

Moisture content is a critical factor in assessing the quality features, acceptability and shelf-life stability of sugar and fat-based baked goods. The moisture content of the oyster mushroom sponge cake is presented in Table 3. The moisture level of the cake samples varied between 25.71 and 26.64%. F_3 exhibited the highest moisture content (26.64%), while the control sample recorded the lowest (25.71%).

Similarly, Dhalagade *et al*. (2020) reported an increase in the moisture content of cookies with the addition of mushroom powder concentration. Al-zamani *et al*. (2022) discovered that the moisture content of mushroom cake rose with higher concentrations of mushroom powder. The rise in moisture content corresponding to the elevated mushroom flour concentration may be attributed to the augmented protein and fiber content, which enhances water absorption and retention in the cake, even after heat treatment. The incorporation of oyster mushroom flour enhances water absorption and retention capacity due to the presence of polar amino acids, resulting in increased moisture content.

The ash content reflects the total mineral composition of a food product. An increase in ash values therefore indicates a higher concentration of mineral constituents within the formulation. F_3 exhibited the highest Ash content at 1.88%, followed by 1.51% in F_2, 1.37% in F_1 and 1.16% in F_0 (Table 3). The ash content enhances the metabolism of other components such as protein, carbohydrates and fats. Al-zamani *et al*. (2022) discovered that the ash content of mushroom cake escalated with higher concentrations of mushroom powder. Okafor *et al*. (2012) and Irakiza *et al*. (2021) observed an elevation in ash content with the addition of mushroom powder in fortified bread samples. The elevated ash level of composite cake is due to the mushrooms being a substantial source of minerals.

Protein is a vital component necessary for optimal bodily function, as it supplies energy upon digestion and metabolism. Table 3 demonstrates that the crude protein content of the formulated cake dramatically increased with the addition of oyster mushroom powder. The highest protein content of 8.42 was recorded in F_3, followed by 7.75 in F_2, 7.17 in F_1 and 6.60 in F_0, which acted as the control

Table 2: Proximate composition oyster mushroom powder.

Parameters	Values
Moisture (%)	4.89±0.05^{e}
Ash (%)	1.28±0.04^{g}
Protein (%)	17.93±0.12^{d}
Fat (%)	3.58±0.02^{f}
Fiber (%)	21.44±0.01^{c}
Carbohydrate (%)	50.88±0.09^{b}
Energy (Kcal/100 g)	307.46±0.14^{a}

Note: Each experiment was conducted in triplicate (n=3) and the results were expressed in terms of mean±SD. Using SPPS version 25.0 software, ANOVA (One-way analysis of variance) and tukey's test (significantly different at $p \leq 0.05$) were performed.

Table 3: Proximate composition of developed mushroom sponge cake.

Parameters	Sample			
	F_0	F_1	F_2	F_3
Moisture (%)	25.71± 0.01^{d}	25.91± 0.01^{c}	26.27± 0.02^{b}	26.64±0.03^{a}
Ash (%)	1.16±0.02^{d}	1.37±0.01^{c}	1.51±0.01^{b}	1.88±0.01^{a}
Protein (%)	6.60±0.01^{d}	7.17±0.04^{c}	7.75±0.02^{b}	8.42±0.02^{a}
Fat (%)	4.41±0.01^{d}	4.56±0.05^{c}	4.75±0.02^{b}	4.84±0.04^{a}
Fiber (%)	3.72±0.02^{c}	3.90±0.02^{b}	3.91±0.03^{b}	4.08±0.06^{a}
Carbohydrate (%)	58.27±0.02^{a}	57.30±0.04^{b}	56.05±0.01^{c}	55.07±0.02^{d}
Energy (Kcal/100g)	299.17±0.04^{a}	298.92±0.02^{b}	298.53±0.01^{b}	281.52±0.01^{b}

Note: F_0= control (0% of mushroom powder); F_1 =4% of mushroom powder; F_2=8% of mushroom powder; F_3=12% of mushroom powder; Each experiment was conducted in triplicate (n = 3) and the results were expressed in terms of mean±SD. Using SPPS version 25.0 software, ANOVA (One-way analysis of variance) and tukey's test (significantly different at $p \leq 0.05$) were performed.

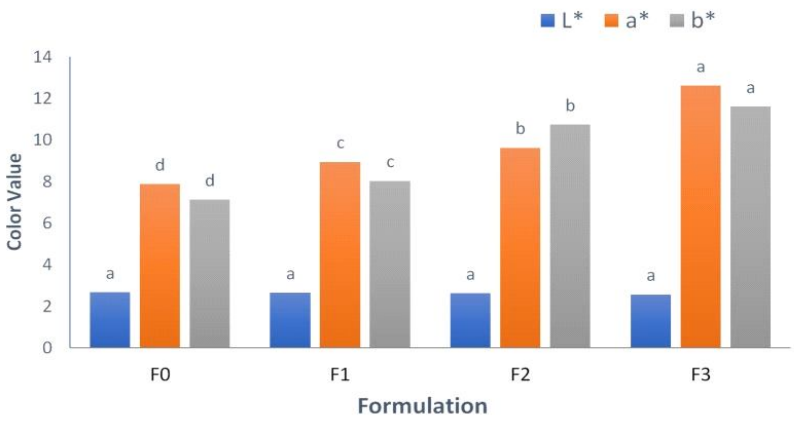
with the lowest protein value of 6.60. Al-zamani *et al*. (2022) discovered that the protein content augmented with higher concentrations of mushroom flour in the cake formulation combined with wheat flour. The increase in protein content was mostly attributable to the superior protein concentration of mushroom powder compared to wheat flour. Irakiza *et al*. (2021) noted that the addition of mushroom flour enhanced the crude protein content of breads. Gupta *et al*. (2011) discovered that the crude protein content of the cookies rose as the substitution levels of barley decreased and conversely.

Fat is a crucial component that serves as a lubricating agent, improving the texture, rheology and general palatability of the final product. The fat content of the formulated cake increased with the incorporation of oyster mushroom powder and a reduction in wheat flour percentage (Table 3). The fat level of the cake samples varied from 4.41% to 4.84%. F_4 exhibited the greatest fat content percentage at 4.84%, whereas the Control sample recorded the lowest at 4.41%. Al-zamani *et al*. (2022) discovered that the fat content escalated with the rising concentration of mushroom flour in the cake formulation relative to wheat flour. The diminishing fat content of the cookie samples correlated with the increasing proportion of mushroom powder in the composite cookie formulation. Ojinnaka *et al*. (2018) and Bello *et al*. (2017) observed a comparable upward trend in fat content corresponding to the rising concentration of mushroom flour.

Fiber is an indigestible carbohydrate present in plant-based meals that is crucial for digestive health and can assist in regulating blood sugar, lowering cholesterol and diminishing the risk of some malignancies. The crude fiber content of the created cake greatly rose with the augmentation of mushroom powder and the reduction of wheat flour concentration (Table 3). Formula F_3 exhibited a superior fiber content of 4.08%, followed by Formula F_2 at 3.91%, Formula F_1 at 3.90% and Formula F_0 at 3.72%. Additionally, Formula F_0 (Control) demonstrated the lowest ash level at 3.72%. Bello *et al*. (2017), Dhalagade *et al*. (2020) and Kumar and Barmanray (2007) observed a comparable upward trend in crude fiber content corresponding to higher concentrations of mushroom flour.

Carbohydrates encompass sugars, starches and fibers present in diets that supply energy to the body. The total carbohydrate content of the created cake was reduced with the addition of mushroom powder and a decrease in wheat flour concentration (Table 3). Formula F_0 (Control) exhibited the highest carbohydrate content at 58.27%, followed by Formula F_1 at 57.30%, Formula F_2 at 56.05% and Formula F_3 at 55.07%, which represented the lowest carbohydrate level. Al-zamani *et al*. (2022) discovered that the carbohydrate content diminishes when the concentration of mushroom flour in the cake formulation increases relative to wheat flour. The low carbohydrate content of cake offers several health benefits, as it can enhance intestinal digestion and alleviate constipation. Zienab *et al*. (2015) also discovered a reduction in total carbohydrate content in cake blends that included button mushroom flour, as well as mushroom and turmeric powder. Ojinnaka *et al*. (2018) discovered that the carbohydrate content of the cookies diminished with the addition of wheat–cocoyam mushroom blends.

Food energy denotes the complete caloric value obtainable from food through oxidation. Table 3 demonstrates the total energy value of sponge cake created with oyster mushroom powder. The lowest energy value of 281.53 Kcal was recorded in Formula F_3, followed by values of 298.53 Kcal



Note: F_0= control (0% of Mushroom powder); F_1=4% of Mushroom powder; F_2=8% of Mushroom powder; F_3=12% of Mushroom powder; Each experiment was conducted in triplicate (n = 3) and the results were expressed in terms of mean±SD. Using SPPS version 25.0 software, ANOVA (One-way analysis of variance) and tukey's test (significantly different at $p \leq 0.05$) were performed. L*: black to white; a*: Green to red-purple; b*: yellow to blue.

Fig 1: Color properties of developed mushroom sponge cake.

in Formula F_2, 298.92 Kcal in Formula F_1 and 299.17 Kcal in Formula F_0 (Control), which exhibited the highest energy value of 299.17 Kcal. Al-zamani *et al*. (2022) discovered that the total energy diminishes when the concentration of Oyster mushroom powder increases. Kumar and Barmanray (2007) noted a reduction in the overall calorific value as the concentration of mushroom flour increased. The reduction in calorie value may result from the diminished gluten content in mushroom flour. The protein, carbohydrate and fat composition contributed to the overall energy content of the cake. Cookies are energy-dense foods primarily consumed as snacks between meals.

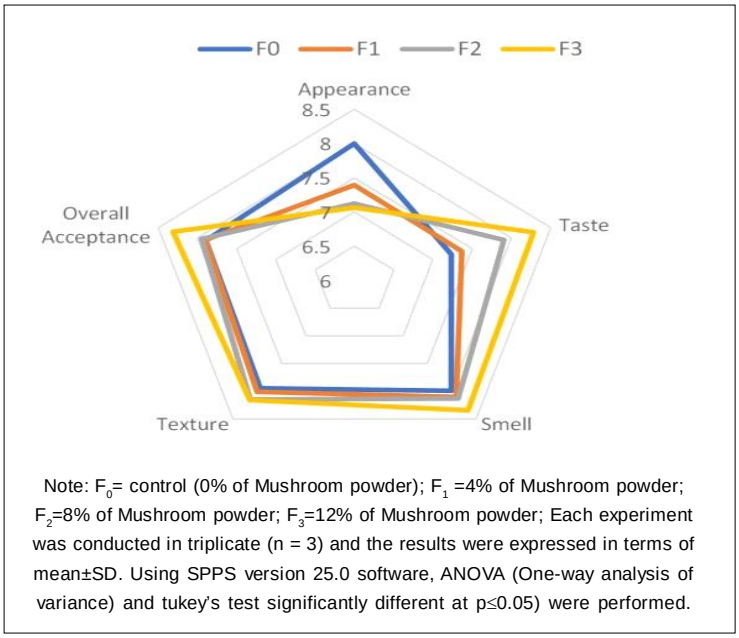
Color of sponge cake

Color is a critical element in the incorporation of byproducts into novel food formulations, as significant alterations in this characteristic within the food matrix may result in consumer aversion. The color metrics of oyster mushroom sponge cakes were represented by L* (lightness), a* (redness) and b* (yellowness). Fig 1 demonstrated that the L* value of the sponge cakes diminished, although the a* and b* values increased markedly with the addition of mushroom powder. Formulation F_0 had a higher L* value of 2.67, while formulation F_3 displayed a lower L* value of 2.56. Simultaneously, formulation F_0 exhibited the lowest a* and b* values of 7.87 and 7.12, respectively, while formulation F_3 had the greatest a* and b* values of 12.60 and 11.59, respectively. Chen *et al*. (2021) observed a similar pattern, noting that the addition of mushroom flour to the cookies resulted in elevated a* and b* values and a reduction in L* values. Irakiza *et al*. (2021) also observed an increase in a* and b* values and a decrease in L* in bread containing mushroom flour. Sharma and Gujral (2011) noted a reduction in L* values alongside an increase in a* and b* values corresponding to a drop in button mushroom flour concentration and vice versa. Baking may lead to a reduction in L* values and an elevation in a* and b* values, relative to the comparable dough. The carameli-zation of sugar and Maillard reaction are responsible for the formation of brown pigments during baking (Laguna *et al*., 2011).

Sensory attributes of developed oyster mushroom cake

The cake samples infused with mushroom powder were assessed for their look, aroma, flavor, texture and general acceptability on a 9-point hedonic scale. Fig 2 illustrates the average sensory scores together with their corresponding ranks. A 10% sample exhibited the greatest ratings in color, texture and overall acceptability (7.89-8.31). However, the sample with 12% mushroom powder had the best overall acceptance, scoring 8.31. The sensory evaluations of the control sample, at 4%, 8% and 12%, yielded scores of 7.89, 7.90, 7.95 and 8.31, respectively, indicating a degree of acceptability for these three cake samples. The highest appearance value was 8 in F_0 (Control), followed by F_1, F_2 and F_3 with values of 7.39, 7.12 and 7.06, respectively, indicating that the control sample (0%) outperformed the mushroom powder-enriched cake. The highest test value was 8.28 in F_3 (12%), followed by Control, F_0 and F_2, with test values of 7.23, 7.37 and 7.9, respectively. The lowest odor value was 7.99 in the Control group (0%), followed by F_0 at 8.1, F_2 at 8.13 and F_3 at 8.34. The highest Texture value was 8.16 in F_3, followed by Control, F_0 and F_1 with values of 7.94, 8.01 and 8.15, respectively.

The sensory evaluation revealed an overall acceptability score of 8.31 for the Oyster mushroom-based sponge cake in F_3, while formula F_0 had the lowest score of 7.89. The fluctuation in the overall acceptability score of the baked cake may be attributed to the color, texture and flavor associated with the wheat flour and mushroom powder.



Note: F_0= control (0% of Mushroom powder); F_1 =4% of Mushroom powder; F_2=8% of Mushroom powder; F_3=12% of Mushroom powder; Each experiment was conducted in triplicate (n = 3) and the results were expressed in terms of mean±SD. Using SPPS version 25.0 software, ANOVA (One-way analysis of variance) and tukey's test significantly different at $p \leq 0.05$) were performed.

Fig 2: Sensory attributes of developed mushroom sponge cake.

The sensory study results demonstrate that substituting up to 12% of flour in cake with mushroom powder is deemed quite satisfactory. The findings align with those of Sheikh *et al*. (2010) who indicated no significant differences in the reinforcement of sponge cake with mushrooms. The sensory evaluation revealed that the surface color and appearance of the control samples were optimized with 12% oyster mushroom powder (F_3). It was also found that in formula F_1, F_2 and F_3, the incorporation of oyster mushroom powder inclusion led to the substantially darker color. This may be ascribed to enzymatic browning, perhaps leading to products being deemed overbaked and unsatisfactory to certain panelists. The cake exhibited increased softness with higher concentrations of oyster mushroom powder. This is due to the elevated water absorption capacity. Nevertheless, as the concentration of mushroom powder increased, the cookies exhibited a little bitter flavor, perhaps attributable to the elevated polyphenol content. Majeed *et al*. (2017) identified a statistically significant disparity in the sensory evaluation of breads made with MF. Kulkarni *et al*. (2010) noted a rise in the overall acceptability of cookies reinforced with mushrooms at a substitution level of up to 10%. However, further additions negatively impacted the overall acceptability of cookies. Consequently, the incorporation of 10% mushroom powder yields superior cookies that are significantly more acceptable than the reference sample, exhibiting enhanced characteristics. Microbial examination. The microorganisms found in the finished cake serve as indicators of the sanitary quality of the raw materials, manufacturing methods and storage conditions. The results of this rise can be attributable to enhanced moisture content, water activity and secondary metabolites associated with oyster mushroom powder.

CONCLUSION

The present investigation revealed that the partial replacement of wheat flour with oyster mushroom powder in sponge cake recipes markedly improved the nutritional and sensory attributes of the product. Incremental addition of mushroom powder (4 to 12%) resulted in a substantial increase ($p \leq 0.05$) in the levels of protein, fat, ash and fiber, whereas carbs exhibited a decrease.F_3, with 12% mushroom powder, exhibited the optimal equilibrium between consumer acceptance and nutritional improvement among the formulations. Increased mushroom incorporation, as per sensory assessment, maintained the preferred texture and general acceptability while marginally altering the color and taste. Consequently, including up to 12% (F_3) oyster mushroom powder into sponge cake is an effective approach to create a value-added, nutritionally enhanced bakery product with satisfactory physicochemical and sensory attributes.

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Disclaimers

The authors alone are responsible for the views and information presented in this article.

Informed consent

No human and animal study were conducted.

Conflict of interest

The authors declare no conflicts of interest and confirm that no funding influenced the study.

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