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Development of protein-enriched cake incorporated with mushroom powder (*Agaricus bisporus)*

Zakarya Al-zamani[1], Arvind Kumar[1*], Sam Al-dalali[2], Hamzah Aleryani[3], Abdulah Abdo[4]
[1] Department of Dairy Science and Food Technology Institute of Agricultural Sciences, Banaras Hindu University Varanasi, India
[2] School of Food and Biological Engineering Hefei University of Technology, Hefei, China
[3] College of Food Science and Technology Yunnan Agricultural University, Kunming-China
[4] College of Food Science and Technology Hebei Agricultural University, Baoding, China

Abstract
This study aimed to evaluate the effect of adding fresh mushrooms powder on the physicochemical and nutritional qualities of cakes. The mushroom powder was incorporated in cake formulations at 0%, 5%, 10%, and 15% by weight. Various quantities of mushroom powder have been shown to affect cakes' physicochemical and nutritional qualities. In which mushroom powder cake had higher protein and fat content and lower carbohydrate content than the control cake. Sensory analysis results showed that the mushroom powder cake had a distinct color and flavor from the control cake. The texture of the mushroom powder cakes was similar to the control cake. The cake containing 10% to 15% mushroom powder was found to be the most satisfactory. It can be concluded that the cake containing 10-15% of mushroom powder could be used industrially in cake compositions to achieve acceptable cake quality.

Keywords: mushroom powder, cake quality, protein, texture analysis

Introduction

Mushrooms are incredibly popular in different parts of the world. They are well appreciated for their exquisite taste and flavor and consumed in fresh and processed forms (Stamets,2000) [1]. Mushrooms are a rich source of protein, vitamins, and minerals but are low in carbohydrates and fats, making mushrooms ideal for diabetics and people who want to lose extra pounds. Mushrooms are also a good source of energy (Kakon*et al*,; 2012, (Croan, 2004) [2,3].In every part of the world, the mushroom output is expanding, and mushrooms have emerged as one of the most significant horticultural crops on the planet. There are over 2000 different kinds of mushrooms, at least 1,450 edibles and 25 of which are widely acknowledged as food sources (Chang and Miles, 2008, Ergonul *et al*.,2013) [4,5].Agro- and industrial waste can be transformed into very nutritious foods that are high in protein and other nutrients when mushrooms are grown on them. Mushrooms have nutritional properties that fall between meat and vegetables (W. Radzki, 2016) [6]. Edible mushrooms have been consumed as food by humans for thousands of years, and they are highly appreciated for their texture, flavor, and some medicinal and tonic properties (Manzi *et al*., 2001) [7]. However, recently, the public has become more aware of mushrooms as a nutritious meal and a significant source of bioactive compounds with potential medical applications (Zhang, 1996) [8].It is used in conjunction with other herbs as a tonic, and it can be cooked with dishes to produce extremely nutritious soups.

The powdered form of mushroom concentrates can be frozen or spray-dried to create granular powders that are easy to handle and transport. Some mushrooms are used to manufacture snack cakes for the elderly, which are particularly popular in Japan (Minzuno *et al*., 1995) [9]. Among the many minerals found in mushrooms are iron, copper, calcium, potassium, zinc, and other trace elements besides vitamin D (Singh *et al*., 1995) [10]. Mushrooms are used as food and medicine worldwide, and this is especially true nowadays. Because they are a food source, mushrooms have high nutritional values (Aremu *et al*., 2009) [11]. For every 100 grams of mushroom, they contain 3.6 grams of protein, 0.26 mg of vitamin B12, 0.3 grams of fat, 1.5 grams of carbohydrate, 2.5 grams of dietary fiber, 5.0 grams of ash, and a host of other vitamins in exceptionally high concentrations (Parvin, Rezoana, *et al*, 2020) [12]. *Agaricusbisporus* is the most frequently farmed mushroom globally, followed by *Lentinusedodes*, *Pleurotus spp*., and *Flammulina velutipes*, which are also among the most widely cultivated. It is estimated that mushrooms' global output is expanding rapidly; China is the world's top producer (Patel, Naraian, & Singh, 2012) [13]. In 2019, the global commercial output of mushrooms reached 11.89 million tonnes, with China accounting for the majority of the production (8938814 tones), which accounted for 75% of the overall production in the year. (Tubiello.; 2013) [14] provided the source.

Due to the high moisture content of fresh mushrooms of about 87 to 95% water, they are perishable and cannot be stored for more than 24 h in ambient conditions. Therefore, it must be preserved in some way. Effective preservation methods extend the shelf life of mushrooms and diversify the product for consumers. Preservation may also be beneficial if the mushrooms are used as an ingredient to produce other foods such as fortification of biscuits and cake (Arora *et al*., 2003) [15]. Drying is the most widely used method for the long-term preservation of agricultural products, including mushrooms, because it prolongs the shelf-life of food and preserves its other qualities (Pandey & Agrawal, 2000; Tulek, 2011) [16,17].Convenient, health-promoting foods are in high demand these days due to the growing health-consciousness of the population. Using powdered dried fruits and vegetables, cereal producers can increase the nutritional value of their products while lowering the cost.

All over the world, baked goods such as bread, cakes, and biscuits are consumed. By incorporating high-quality sources of vitamins, minerals, polyphenols, and fibers into these products, it is possible to enrich them with these nutrients and make them more nutritious. A good example of such a source is dried mushrooms, which have much promise. Using mushrooms as a starting point, Rai and Arumuganathan (2008) [18]. investigated the possibility of value-added products. In addition to biscuits and soup powder, the company has developed nuggets and noodles, candies and pickles, and ketchup using mushrooms powder as an ingredient.

Mushroom powder holds a lot of promise in terms of its potential application as an ingredient in various culinary businesses, including breakfast cereals and baked products such as cookies and cakes. Investigations have been conducted into the usage of dried mushrooms in baked goods such as bread, biscuits, and cakes. By incorporating mushroom powder into bakery products, a nutritionally valuable product that many consumers can consume with almost every meal can be obtained. In the current study, the development of a protein-enriched cake incorporating mushroom powder was undertaken with the following objectives:

1. To study the drying characteristics of mushroom powder.
2. To optimize the ingredients for the mushroom powder cake.

Materials and Methods

Chemicals and Raw Materials

Fresh button (*Agaricus bisporus*) were obtained from a local market (spencer, Varanasi, India). Chemicals and solvents used in this study were purchased from (MerckKGaA, Darmstadt, Germany). Wheat flour, sugar, baking powder, sunflower oil, vanillin, milk, salt, and other ingredients were collected from the local market. High-density polyethylene bags were used for the package and storage of samples. Other minor ingredients were used from laboratory stocks.

Mushroom Powder Preparation

Mushrooms were prepared according to the method described by Kumar & Arora. (2019) [19]. In brief, mushrooms were washed with clean water to remove dirt and other undesirable suspended matter before use. Fresh and clean mushroom samples were cut into small slices (3 mm) using a knife and then blanched in hot water at 90 °C for 3 min, which contains 2% sodium chloride; after that, the slices were washed with clean water and spread on drying plates in a hot air oven at 60°C until constant moisture was reached from 10% to 13%. Then the mushroom slices were cooled to room temperature and grind with a blender to get the mushroom powder, fill it in a polyethylene bag, and store it at 4°C for the production and preparation of the cake (Fig. 1).

Preparation of protein-enriched cake

The cake was prepared from wheat flour with partial replacement using three different levels of dried mushroom powder (5%, 10%, and 15%).

All weights of flour, mushroom powder, and the rest of the ingredients (milk sugar, oil, baking powder, and salt) for all transactions were taken accurately. Firstly, the flour, mushroom powder, and baking powder were mixed in a separate bowl.

Secondly, the milk, sugar, and oil were mixed for 10 min, and then the first mixture was gradually added with continuous mixing until the desired consistency was obtained; the mixture was poured into the mold for cake production and entered the convection oven at a temperature of 170 °C for 15 min.

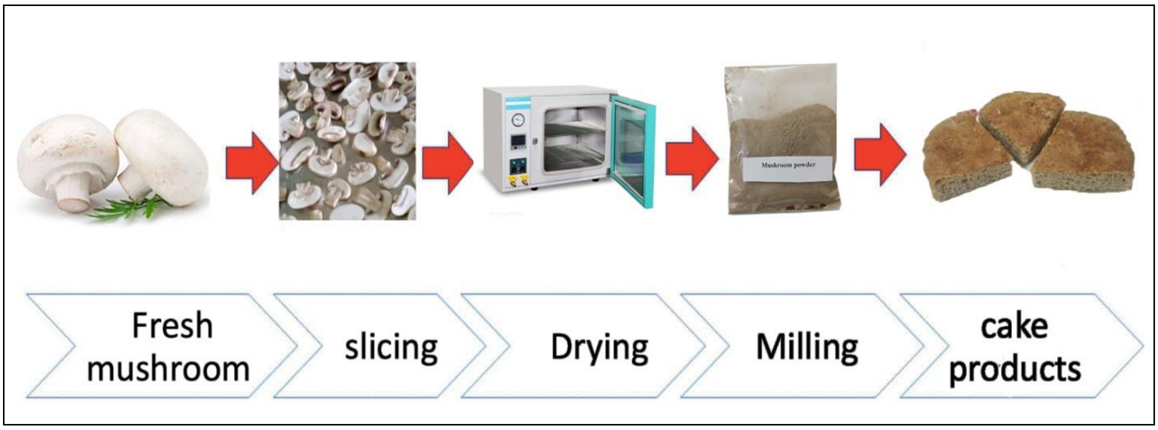

Fig 1: Production of mushroom powder Enriched Cake

Analysis of mushroom powder cake

The moisture, ash, protein, fat, and carbohydrate content of mushroom powder cake prepared by incorporating mushroom powder were analyzed. Moisture, ash, carbohydrate, protein, and lipid content were determined according to the methods described by Rangana (1994), AOAC (2005) [20, 21]. All analyses were performed in triplicate, and the results are expressed as the mean values.

Optimization of Mushroom Powder content in Cake Products

The composition of the cake containing mushroom powder is shown in Table 1. The Table shows the basic formula for the regular cake, which replaced the wheat flour by using three different amounts (5%, 10%, and 15%) of mushroom powder in addition to the control treatment

Table 1: Ingredients of the protein-enriched cake incorporated with mushroom powder

Ingredients	T1	T2	T3	T4
Wheat flour(g)	200	190	180	170
Mushroom powder(g)	0	10	20	30
Sugar(g)	140	140	140	140
Oil (g)	60	60	60	60
Milk (g)	150	150	150	150
Baking powder (mg)	60	60	60	60
Vanilla essence (mL)	1.5	1.5	1.5	1.5

Textural and rheological properties of mushroom powder cake

Texture Profile Analysis is a popular double compression test for determining the textural properties of foods. The textural properties, i.e., hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness, and resilience, were determined using a texture analyzer (TA, TX plus Stable Micro Systems, Surrey, UK).A cake sample of length 3 cm was used. Test mode was compression type. The pre-test, post-test, and post-test speeds were 1.00 mm/sec, 5.00 mm/sec, and 5.00 mm/sec, respectively. Target distance and trigger force were set at 10.000 mm and 5.0 g, respectively. The textural properties were evaluated using Texture Exponent Lite Software. The analyzer was linked to a computer that recorded the data via the software program.

4 Sensory Evaluation of Cakes

The cakes were assessed using organoleptic methods for their coloration, flavor, texture, and general acceptability. In addition, a 1-9 scale hedonic rating test was used to determine the degree of acceptability of cakes containing mushroom powder at various levels of concentration. Twenty panelists were each given a slice of cake from each batch, with the slices being coded randomly. The taste panelists were asked to rate the sample on a 1-9 scale for color, flavor, texture, and overall acceptability, with 9 representing extreme liking, 8 representing very liking, 7 representing moderate liking, 6 representing slight liking, 5 representing neither liking nor disliking, 4 representing slight dislike, 3 representing moderate dislike, 2 representing very dislike, and 1 representing extremely dislike. Duncan's New Multiple Range Test Procedures and the Analysis of Variance procedures of the Statistical Analysis system were used to assess the results (Gupta, 1976) [22]

Statistical Analysis

All analyses were performed in triplicate, and the results were presented as a mean value with standard deviation. The sensory evaluation results were evaluated using one-way analysis of variance (ANOVA) and the statistical software SAS.

Results and Discussion

Composition of mushroom powder

As shown in Table 2. the contains of protein, ash, and total carbohydrate of mushroom powder were more or less similar to the result reported by Kumar & Barmanray (2007) [23].Another study conducted by Cheung (2013) [24] found that the contents of bottom mushroom powder were 6.8 % moisture, 32.5 % protein, 1.6% fat, 7.5% ash, and 51-62% total carbohydrate, which is slightly different from our study, perhaps due to the percentage of moisture and drying technique.

Table 2: Chemical composition of mushroom powder

Components	Mushroom powder
Moisture (%)	10.12±0.56
Protein (%)	26.28±0.46
Fat (%)	3.353±0.23
Ash (%)	9.22±0.47
Total carbohydrate by difference (%)	51.03±0.82

*All the values are mean ±SD of triplicate samples

Sensory Evaluation of Mushroom Cake

The cake samples enriched with mushroom powder were evaluated for their color, appearance, aroma, taste, crispiness, and overall acceptability using a 9-point hedonic scale. Table 3 depicts the average sensory scores with ranks 10% sample recorded the highest color, texture, and overall acceptability (8.42, 8.28, 8.23). But sample with 15% mushroom powder recorded the highest flavor (8.26). The sensory results of the control sample, 5%, and 10%, were in the range of (7.83 - 8.28), which indicates that these three cake samples are acceptable to some extent. The sensory analysis results indicate that the partial replacement of flour in cake with up to 10% mushroom powder is considered very satisfying. These results are similar to the study conducted by Sheikh *et al*.; (2010) [25] and Arora (2017) [25, 26] who reported no significant differences in the reinforcement of sponge cake with mushrooms.

Table 3: Sensory Evaluation of Mushroom Powder Cake

Samples	Appearance &color	Texture& body	Flavor	Overall acceptance
T1	$7.73{\pm}0.23^{a}$	$7.84{\pm}0.19^{a}$	$7.65{\pm}0.21^{a}$	$7.83{\pm}0.19^{a}$
T2	$8.05{\pm}0.77^{b}$	$8.10{\pm}0.24^{b}$	$8.10{\pm}0.22^{b}$	$8.06{\pm}0.17^{a}$
T3	$8.42{\pm}0.26^{b}$	$8.23{\pm}0.25^{b}$	$8.21{\pm}0.24^{b}$	$8.28{\pm}0.25^{ab}$
T4	$7.71{\pm}0.24^{a}$	$7.97{\pm}0.19^{a}$	$8.26{\pm}0.99^{b}$	$7.98{\pm}0.15^{a}$

*Values are mean ±SD of ten panelists

* Values with different superscripts in the column are significantly different.

Texture Analysis of Mushroom Powder Cake

Through the results shown in Table 4, it can be seen that the hardness of the measured cake samples became more solid with the increase in the levels of mushroom powder which indicates that the hardness of the cake is directly related to the contents of protein, fat, and ash.

Cohesiveness: Cohesiveness quantifies the internal resistance of food structure. Cohesiveness is the ability of a material to stick to itself. TPA results showed increasing cake cohesiveness with an increased level of button mushroom powder.

Springiness: Springiness measures elasticity by determining the extent of recovery between the first and second compression. Resilience is the ratio of recoverable energy as the first compression is relieved. TPA results showed no significant difference in the cake springiness and resilience with an increased level of button mushroom powder.

Gumminess is determined by hardness multiplied by cohesiveness. The chewiness is determined by gumminess multiplied by springiness, representing the energy needed to disintegrate a food for swallowing. TPA results showed increasing cake gumminess and chewiness with an increased level of button mushroom powder. Overall, the hardness, cohesion, and flexibility increased with the increase in the percentage of mushroom powder, while the gum and chewing decreased with the increasing percentage of mushroom powder.

Table 4: Texture Profile Analysis of Mushroom Powder Cake

Parameters	T1	T2	T3	T4
Hardness	3.009	12.369	150.04	162.63
Adhesiveness	12.529	50.205	147.55	229.12
Springiness	0.53	0.864	0.834	0.984
Cohesiveness	0.47	0.707	0.664	0.584
Gumminess	0.664	11.866	46.997	55.969
Chewiness	14.028	9.991	42.671	48.809
Resilience	0.401	0.359	0.316	0.329

*Values are mean of triplicate samples

Proximate Composition of cakes incorporated with mushroom powder

The chemical composition of the mushroom cake was studied, and its components under different treatments are presented in Table 5. Table 5 shows the results of the chemical analysis of the different cake samples. We note from Table 5the increased moisture, protein, fat, and ash content of the cake samples with the increase of mushroom powder. All samples fortified with mushroom powder were higher than the control cake in moisture, protein, fat, and ash. In contrast, the carbohydrate content of the control cake sample was higher than that of all the different cakes enriched with mushroom powder. Where cake containing 15% mushroom powder achieved the highest percentage of (protein15.05%, fat 15.96%, and ash 2.17%) compared with the control sample (protein 9.86%, fat13.2%, and ash1.64%) that agreement with results reported by Salehi *et al*. (2016) [27] in their study which conducted on added dried button mushroom to the spongy cake that shown increased of moisture, protein, fat, and ash with decreased of carbohydrate.

This study showed that the higher the percentage of mushroom powder in the cake, the higher the percentage of protein, moisture, fat, ash, and the lower ratio of total carbohydrates. This increase may be due to the inherent nutritional composition of mushrooms. Arora (2017) [26] reported that using 20% of mushroom powder to cake led to increases in the percentage of moisture, protein, and ash (21.21%, 12.32%, and 5.49%), respectively. compared to the control sample.

Table 5: Composition of the Cakes Containing Different Levels of Mushroom Powder

Components	T1	T2	T3	T4
Moisture (%)	23.74 ± 0.59^a	25 ± 0.57^b	27.58 ± 0.38^c	28.26 ± 0.45^c
Protein (%)	9.86 ± 0.64^a	11.26 ± 0.56^b	13.04 ± 0.55^c	15.05 ± 0.48^d
Fat (%)	13.2 ± 0.72^a	13.68 ± 0.68^a	15.04 ± 0.64^b	15.96 ± 0.77^b
Ash (%)	1.64 ± 0.10^a	1.18 ± 0.05^b	2 ± 0.11^c	2.17 ± 0.34^c
Total Carbohydrate (%)	52.56 ± 0.67^a	48.88 ± 0.88^b	42.34 ± 0.69^c	39.73 ± 0.57^d
Reducing sugar (%)	4.21 ± 0.34^a	4.82 ± 0.46^a	5.54 ± 0.38^b	6.25 ± 0.44^c

*All the values are mean ±SD of triplicate samples.
*Values with different superscripts in rows are significantly different**.**

Conclusion

The addition of mushroom powder enhanced the cake's protein, fat, ash, and fiber levels. The protein, fat, ash, and fiber content in the cake increased as the level of mushroom powder in the preparation increased from 5% to 15%, while the sugar content decreased. The organoleptic trait test revealed that cakes' color, flavor, texture, and general acceptability varied greatly depending on the amount of mushroom powder used, but that partial substitution of wheat flour with 10% mushroom powder was more satisfying. According to the findings, 10% mushroom powder can be successfully included in the cake without eggs to improve the nutritional quality while maintaining acceptable sensory characteristics.

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