

Physicochemical Properties and Sensory Evaluation of Sponge Cake Supplemented with Hot Air and Freeze Dried Oyster Mushroom (*Pleurotus sajor-caju*)

Rana Das^{1*}, Manobendro Sarker², Mahmuda Begum Lata³, Md. Atiqul Islam⁴,
Md. Azmain Al Faik¹, Shagor Sarkar⁵

¹Department of Food Engineering and Technology, State University of Bangladesh, Dhaka, Bangladesh

²Department of Biomass Energy Engineering, Shanghai Jiao Tong University, Shanghai, China

³Department of Food Engineering and Tea Technology, Shahjalal University of Science and Technology, Sylhet, Bangladesh

⁴Department of Food Science and Technology, Sunchon National University, Sunchon, South Korea

⁵Department of Biosystems Engineering, Gyeongsang National University, Jinju, Republic of Korea

Email: *ranasust8@gmail.com

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Abstract

The study was aimed to enhance the nutritional quality of sponge cakes with oyster mushroom (*Pleurotus sajor-caju*). In this study, the physicochemical, functional, and sensory properties of cake supplemented with five different levels of mushroom powder (0 as control, 5%, 7%, 10%, and 12%) were evaluated. The results revealed that both hot air dried (HD) and freeze dried (FD) mushroom powder contained a higher amount of protein, fat, ash and fiber content compared with wheat flour used in cake, but the carbohydrate and moisture content showed the reverse trend. The study also found that increasing the level of fortification from 0% to 12% mushroom powder also increased the protein, fat, ash, and fiber content in the cake. FD mushroom powder significantly ($p \leq 0.05$) recorded the highest protein (11.72% - 15.16%), fat (20.01% - 21.9%), ash (1.75% - 1.92%), and fiber (1.39% - 1.74%) with increasing the level of supplementation from 5% - 12%. In contrast, carbohydrate content of cake decreased from 34.13% - 31.15% with increasing the level of FD mushroom from 5% - 12%. Also, the volume and weight of the cake with FD mushroom were higher compared to HD and control sample. The results of sensory evaluation indicated that sponge cake with 10% FD oyster mushroom was rated the most acceptable after the control.

Keywords

Cake, Mushroom, Freeze-Dried Mushroom, Mushroom Powder, Protein, Fiber

1. Introduction

Mushrooms are incredibly popular among different parts of the world. They are well appreciated for their exquisite taste and flavor and consumed both in the fresh and processed forms [1]. Edible mushrooms are low in calories, sodium, fat, and cholesterol, while high in protein, fiber, vitamins, and essential amino acids [2]. Among different varieties, oyster mushroom (*Pleurotus sajor-caju*) is very famous for its saccharidic complex. The saccharidic complex of oyster mushroom is characterized by low content of digestible carbohydrates and by a relatively high content of polysaccharides that take part in the formation of edible fiber [3]. Moreover, a study by Kosanic *et al.* [4] indicated that specific mushrooms can be considered as a source of natural antioxidant, antimicrobial, and anticancer compounds.

Admittedly, a large number of people in developing countries, like Bangladesh suffer from protein deficiency because of the high price of its sources, and also experience the scarcity of fiber in their diet due to lack of proper knowledge. Enrichment of baked products with these supplements is of current need and nutritional demand in the recent scenario because of its availability and cheaper price. Wheat flour which is the basic ingredient of a baked product lacks of several nutrients including vitamins, minerals as well as dietary fiber [5]. Wheat flour also lacks essential amino acids, such as lysine and tryptophan [6]. In this regard, the mushroom powder as a source of protein, ash, and fiber can be added to replace the wheat flour along with other ingredients to make functional food high in demand.

Different drying methods are applied in food industry to make the powder form of the mushroom and each of the drying method has its own unique impact on the structural, physical, chemical and functional properties of mushrooms. Study by Xu and Duan [7] found that freeze dried shiitake mushroom had no change in phenolic content and antioxidant activity compared with that of fresh mushroom. Another study [8] showed that freeze drying could be applied in industrial scale drying of mushroom for the production of functional foods and nutraceuticals.

Therefore, dried mushroom powder can partially substitute the wheat flour by adding up the protein and fiber content, and other nutrients as well in the functional baked goods. However, research works in the development of baked goods with oyster mushroom are still largely unearthed in Bangladesh. The main objective of this study was to develop nutrition-rich cake by incorporation of mushroom powder. And the further assessment was carried out to evaluate the effect of hot air dried (HD) and freeze-dried (FD) mushroom powder on the physicochemical and sensory properties of value-added sponge cake.

2. Materials and Methods

2.1. Chemicals, Solvents, and Ingredients

Chemicals and solvents used in the study were of AR grade, and water was dis-

tilled unless specified otherwise. Wheat flour, sugar, baking powder, shortening (dalda), fresh mushroom, 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.

2.2. Preparation of Mushroom Powder

The mushrooms were washed with clean water to remove dirt, sand and other undesirable materials before use. The fresh, clean mushroom samples of 1kg were placed in a square piece of cotton cloth and tied well before immersing in hot water for blanching at 88°C for 1 min. The samples were then dipped into 25% brine solution for around 60 min. After that, the samples were taken out and left in a jar to drain out before further treatment.

Hot air drying: Sliced mushrooms (1 kg) were spread across stainless steel trays and then subjected to drying in hot air oven (model no. DSO-500D/DSO-500DF) at 60°C and relative air humidity of 75%. Drying was finished when constant moisture content ranging from 10% to 13% was attained. The dried mushroom slices were cooled, packaged in polyethylene bags and stored in ambient conditions for further analysis.

Freeze drying: Freeze drying was performed using a laboratory-scale freeze dryer (Scientz-18ND, Martin Christ, Germany). Mushroom slices were spread on the metal trays and frozen at -40°C for 6 - 8 hrs followed by freeze-drying under the following four steps: 1) Cool-Vacuum (time: 30 min, pressure: 0.2 mbar); 2) Cool-Vacuum (time: 1 hr, pressure: 0.2 mbar); 3) Heat-Shelves (time: 2 hr, pressure: -0.2 mBar, temp: 30 degree); and 4) Heat-Shelves (time: 7 hr, pressure: -0.2 mBar, temp: 30 degree).

2.3. Preparation of Sponge Cake

Sponge cakes were prepared by partially replacing the wheat flour at five different levels of mushroom powder (0%, 5%, 7%, 10%, and 12%) along with other basic formulation such as 50 g sugar powder, 40 g butter, 3.5 g baking powder, 35 g egg, and 1 ml vanilla essence. The flour, mushroom powder, and other ingredients for each cake were weighed accurately, and the sugar and shortening were mixed in a mixing machine for 20 min to produce a cream. Finally the flour, water and other ingredients were mixed in a mixer at low speed (145 rpm) for 10 min to ensure even distribution of the components. The bowl was scrapped and the batter was mixed for an additional two minutes at medium speed (250 rpm). The portion of batter weighing 150 g was scaled into a pre-greased cake pan. All cakes were baked in an electric oven (Bakery Machine CK02C) for 40 min at 170°C.

2.4. Chemical Analysis for Fresh Mushroom, Mushroom Powder, and Value-Added Cakes

The fresh mushroom, powder, and cake prepared by incorporating mushroom powder were analyzed for moisture, ash, protein, fat, carbohydrate contents. The

moisture, ash, and crude fiber contents were determined by the method [9]. Protein content was determined by following the AOAC method [10], where conversion factor was 6.25 and fat content was measured by using this method [11]. The Carbohydrate content of the sample was calculated by difference method [12].

2.5. Functional Properties of Mushroom Powder

The powder of mushrooms was determined for its physical properties such as moisture content, bulk density, yield quality, water retention capacity, swelling power, foaming capacity, emulsifying activity, and oil holding capacity. The yield was calculated using the following formula developed by Negi [13]. The bulk density was determined according to the method described by Butt and Batool [14]. Then swelling index was calculated using the described formula in the study [15]. Foaming capacity was determined following the method [16] with slight modifications. The emulsifying activity was determined as described by Okaka and Potter [17]. Water retention and oil holding capacity was determined according to Brishti *et al.* [18].

2.6. Objective Evaluation of Cakes

Cake volume was initially used as an important parameter of cake quality. The cake volume was determined by the seed displacement method [19]. The weights and specific volume of baked cakes were also measured.

2.7. Sensory Evaluation of Cakes

The sensory evaluation of cake was evaluated for color, flavor, texture, and overall acceptability by a group of 10 panelists. The panelists were asked to rate the different formulated cake present to them. In this case, 9-point hedonic rating test was performed to assess the degree of acceptability of these cakes. This 9-point scale is as follows: 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like or dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely.

2.8. Statistical Analysis

All analyses were carried out in triplicate and the results were given as mean value with standard deviation. The results of sensory evaluation were evaluated by one-way analysis of variance (ANOVA) using statistical software SPSS-20.

3. Results and Discussion

3.1. Composition of Wheat Flour, Fresh Mushroom and Mushroom Powder

The fresh mushrooms were analyzed for moisture, protein, fat, ash, fiber, and total carbohydrate contents shown in **Table 1**. According to **Table 1**, wheat flour had the least protein, fat, fiber, and ash content. The moisture, protein, fat, and

Table 1. Nutritional compositions of wheat flour, fresh mushroom and dried mushroom.

Components	Wheat flour (%)	Mushroom		
		Fresh (%)	HD (%)	FD (%)
Moisture	12.61 ± 0.64	88.1 ± 0.53	12.33 ± 0.15	12.21 ± 0.19
Protein	10.46 ± 0.32	3.18 ± 0.04	19.53 ± 0.20	20.21 ± 0.53
Ash	0.83 ± 0.12	1.32 ± 0.01	3.15 ± 0.13	3.24 ± 0.08
Fat	1.20 ± 0.18	2.12 ± 0.10	3.10 ± 0.04	3.28 ± 0.04
Fiber	0.63 ± 0.10	2.02 ± 0.01	7.20 ± 1.54	7.28 ± 0.02
Carbohydrate	74.27 ± 1.54	3.26 ± 0.52	54.69 ± 0.21	53.78 ± 0.56

*Values are mean ± standard deviation of three replicates. [HD-Hot Air Dried; FD-Freeze Dried].

ash content of mushroom powder were more or less similar to this report [20]. A study [21] found that dried oyster mushroom contained 10.6% water, 15.7% Protein, 2.66% fat, 64.1% carbohydrates, and 7.04% ash. The compositions slightly varied from our study probably due to the drying technique and end moisture percentage. Our study also showed that FD mushroom powder contained the higher percentage of protein, fat, ash and fiber compared to the fresh mushroom and HD mushroom powder, while carbohydrate and moisture contents were in the opposite trend. The proximate value of FD mushroom powder was higher than the HD mushroom sample probably because of direct contact of heat in air drying. A research work [22] found that the quality of HD mushroom was inferior to FD mushroom. Another study [23] indicated that freeze drying was the most effective drying method to retain microstructure and nutritional components of oyster mushroom.

3.2. Functional Properties of HD and FD Mushroom Powder

Figure 1 shows that FD mushroom powder had greater water retention power, foaming capacity, emulsifying activity and oil holding capacity over HD mushroom, but in case of yield and bulk density HD mushroom prevailed. The swelling index reflects the water absorption quality of powders. As a result, FD mushroom powders showed a higher swelling index (0.503 ml/g) than the powders prepared by air drying. Protein content of foodstuffs affects water retention capacity and oil holding capacity according to [14], as protein has both hydrophilic and hydrophobic properties to interact with oil and water in foods. Added to this, carbohydrate content including dietary fiber influences water retention capacity [24]. Some researchers ([25] [26] [27]) reported that the high water retention and oil holding capacity of flour make it desirable for the use in bakery products by improving texture and mouthfeel, enhancing flavor, and reducing moisture and fat loss. Due to the damage of cell structure and loss of fibrous material during blanching, the water retention capacity of HD mushroom samples was reduced to 2.93 ml/g. The study also showed that foaming capacity (17.64%) of FD mushroom powder was higher than HD mushroom powder.

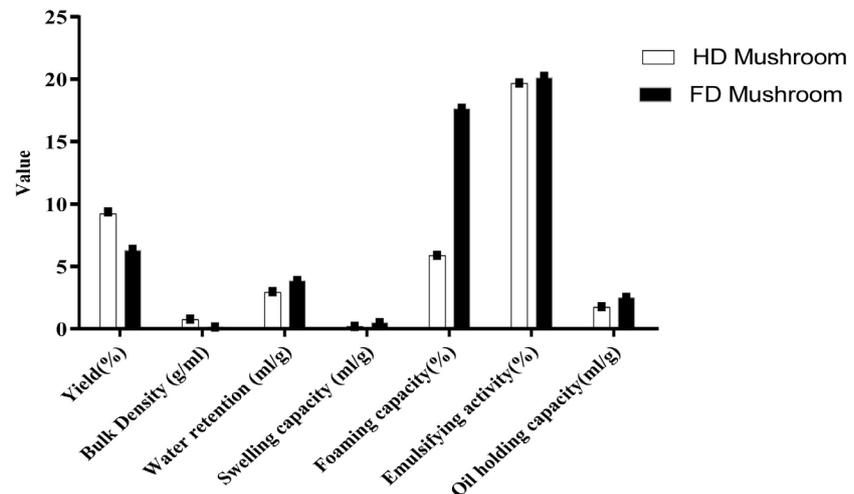


Figure 1. Functional properties of hot air dried (HD) and freeze dried (FD) mushroom.

3.3. Proximate Composition of Cakes Incorporated with Mushroom Powder

The proximate compositions of sponge cakes at five different level of fortification (0%, 5%, 7%, 10%, and 12%) with HD and FD mushrooms are presented in **Table 2**. With increasing the fortification level from 0% to 12%, protein content ranged from 10.20% - 15.08% in the cake with HD mushroom, and 10.20% - 15.16% in the formulated cake with FD mushroom. **Table 2** also shows that each level of substitution with HD and FD mushroom added higher fat, ash and fiber content to the control, while carbohydrate and moisture content were found higher in control than that of substituted cake. The similar trend was also reported in a study [28]. The Analysis indicated that nutritional values of sponge cakes fortified with FD mushroom were always higher than that of HD mushroom at each level, although the carbohydrates and moisture content showed the reverse trend.

3.4. Effect of HD and FD Mushroom Powder on Physical Properties of Cakes

According to **Table 3**, the weight of the cake was linearly increased with an increasing percentage of mushroom powder, where the FD mushroom resulted in a higher weight of cake due to increased water holding capacity than HD mushroom. This variation in cake weight may result from the increased water absorption by the mushroom powder. The cake volume is a quantitative measurement and correlates well with dough handling properties, crumb, texture, freshness, and technological versatility [29]. It can be seen that cake volume decreased and cake weight increased with increasing the level of mushroom powder and subsequently, 12% mushroom powder in the formulations gave lesser volume than those of other samples, and so with the case of specific volume. At the same level of substitution, the cakes enriched with FD mushroom powder had higher moisture content than any other substitution levels.

Table 2. Nutritional composition of sponge cakes containing different level of HD and FD mushroom powder.

Composition (%)	Control		HD mushroom				FD mushroom			
	0%	5%	7%	10%	12%	5%	7%	10%	12%	
Moisture	32.35 ± 0.02	31.35 ± 0.07	30.72 ± 0.02	29.55 ± 0.01	29.02 ± 0.01	31.16 ± 0.04	30.42 ± 0.02	29.45 ± 0.01	28.52 ± 0.01	
Ash	1.73 ± 0.02	1.75 ± 0.01	1.83 ± 0.02	1.87 ± 0.01	1.89 ± 0.002	1.75 ± 0.01	1.85 ± 0.01	1.88 ± 0.01	1.92 ± 0.01	
Protein	10.20 ± 0.02	11.64 ± 0.01	12.35 ± 0.01	14.12 ± 0.02	15.08 ± 0.012	11.72 ± 0.11	12.44 ± 0.01	14.20 ± 0.07	15.16 ± 0.52	
Fat	19.03 ± 0.01	19.93 ± 0.03	20.31 ± 0.03	20.88 ± 0.25	21.50 ± 0.01	20.01 ± 0.02	20.92 ± 0.04	21.50 ± 0.02	21.9 ± 0.01	
Fiber	0.49 ± 0.00	0.51 ± 0.38	0.89 ± 0.20	0.92 ± 0.01	0.95 ± 0.001	1.39 ± 0.001	1.48 ± 0.01	1.53 ± 0.01	1.74 ± 0.74	
Carbohydrates	36.46 ± 0.14	34.23 ± 0.05	33.89 ± 0.08	33.04 ± 0.07	32.50 ± 0.015	34.13 ± 0.11	33.20 ± 0.05	32.25 ± 0.07	31.15 ± 0.05	

*Values are mean ± standard deviation of three replicates. [HD-Hot Air Dried; FD-Freeze Dried].

Table 3. Effect of HD and FD mushroom powder on volume, weight, specific volume of cakes.

Cake type	MP (%)	Weight (g)	Volume (cc)	Specific volume (cc/g)
Control	0	62.43 ± 0.01	155.00 ± 0.03	2.47 ± 0.01
	5	62.50 ± 0.02	154.81 ± 0.01	2.46 ± 0.02
	7	62.75 ± 0.03	154.70 ± 0.00	2.46 ± 0.01
	10	62.77 ± 0.01	154.62 ± 0.07	2.46 ± 0.00
	12	62.81 ± 0.00	153.51 ± 0.01	2.44 ± 0.02
Cake with HD mushroom	5	62.52 ± 0.20	154.80 ± 0.10	2.47 ± 0.02
	7	62.85 ± 0.05	153.50 ± 0.01	2.44 ± 0.00
	10	62.89 ± 0.01	152.95 ± 0.02	2.43 ± 0.03
	12	62.92 ± 0.00	152.22 ± 0.05	2.42 ± 0.02

*Values are mean ± standard deviation of three replicates.

3.5. Sensory Evaluation of Sponge Cakes Fortified with HD and FD Mushroom

The organoleptic properties of sponge cakes at various levels of mushroom powder were evaluated and presented in **Figure 2**. It was found that the cakes formulated with FD mushroom powder were significantly better in sensory evaluation than that with HD mushroom powder, though [23] did not find any significant difference in flavor between HD and FD mushroom. The study also showed that 10% FD mushroom powder enriched cake (indicated as H) secured the second-highest sensory score in color (7.4), flavor (7.9), and texture (7.6) after the control sample, though [30] reported that rice-porridge incorporated with oyster mushroom secured higher scores for aroma, color, appearance and overall acceptability compared to control. In the overall acceptability test, cake enriched with 10% FD mushroom powder again attained the highest score (7.7) among other enrichment formulation.

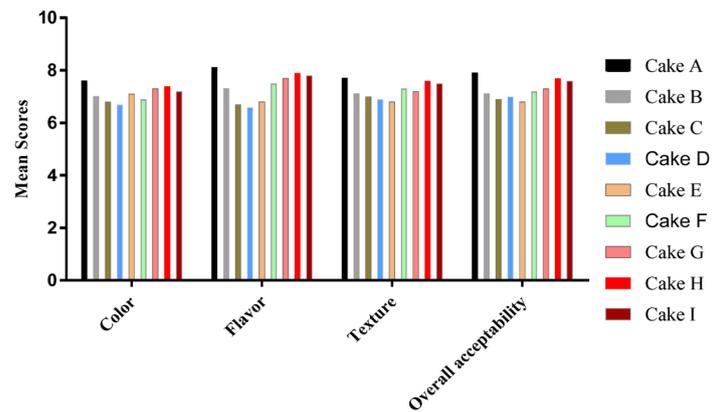


Figure 2. Mean sensory scores of formulated cakes. *[A = 0% (control); B = 5%, C = 7%, D = 10%, E = 12% (HD); F = 5%, G = 7%, H = 10%, I = 12% (FD)].

4. Conclusion

The incorporation of HD and FD mushroom powder resulted in an increase of protein, fat, ash, and fiber content in the sponge cake. Increasing the level of mushroom powder from 5% - 12% in the formulation significantly ($p \leq 0.05$) enhanced the protein, fat, ash, and fiber content of the cake, whereas the sugar content showed reverse trend. However, FD mushroom at each level of fortification added higher nutritional parameter compared to the HD mushroom, except for carbohydrate. Control contained the highest carbohydrate and moisture content. The weight of the cake was increased and the volume was decreased with the increase in the level of mushroom powder, and the cake formulated with FD mushroom powder showed higher weight and lower volume than that with HD mushroom and control. The sensory attribute test revealed that color, flavor, texture and overall acceptability of cakes varied significantly ($p \leq 0.05$) at various levels of mushroom powder, but a partial replacement of wheat flour with 10% FD mushroom is more satisfactory. The present study concluded that 10% FD mushroom powder can be successfully incorporated in sponge cake to enhance the nutritional quality with acceptable sensory attributes.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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