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DEVELOPMENT OF OYSTER MUSHROOM POWDER AND ITS EFFECTS ON PHYSICOCHEMICAL AND RHEOLOGICAL PROPERTIES OF BAKERY PRODUCTS

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ABSTRACT

Wheat flour is staple diet and is mainly consumed in the form of chapatti and bread in Pakistan. Wheat is deficient in lysine which is the first limiting amino acid in wheat. Proteins are indispensable constituents of human diet and are considered crucial for the growth, maintenance and repair of the body tissues. They are one of the essential building blocks of all life. The objective of this study was to prepare the composite flour by blending straight grade flour with oyster mushroom powder (OMP) in different proportions for the baking of bread. The flour was also evaluated for rheological properties. The supplemented bread was subjected to sensory evaluation and physical analysis by Farinograph measurements of the following characteristics affected by mushroom powder: water absorption, dough development time, softening of dough, dough stability and mixing tolerance index. Results showed that OMP increased water absorption capacity of dough with highest absorption recorded in T_5 (66.4%) and minimum in T_0 (56.4%). Dough development time increased with the increasing amount of OMP. It was minimum in T_0 (1.5 min) and maximum in T_5 (4.6 min). The capacity of dough to get soft also increased with increasing treatment level. Dough stability also decreased with increasing level of OMP. Mixing tolerance index was also significantly affected by OMP. Results of amylograph indicated that peak viscosity increased from 1595 to 1700 BU from T_1 (3% mushroom powder) to T_5 (15% mushroom powder) with the increase of OMP.

Keywords: Amylograph, Bakery Products, Farinograph, Mushroom Powder, Protein, Bread

INTRODUCTION

In many cultures, edible mushrooms have been consumed as food and medicine for many years (**Wan Rosil *et al*., 2011; Akbarirad *et al*., 2013**). They constitute a significant food item regarding health, human nutrition and disease prevention (**Chang and Miles, 2004**). It is generally said that "foods and medicines have a common origin" (**Kaul, 2001**). Mushrooms are versatile food items which may be consumed fresh or cooked wholly. Mushrooms have been included in a normal human, diet for so long but currently, amounts consumed have increased to a great extent involving a larger numbers of species. Nowadays, mushrooms are eaten for their distinctive flavor, texture as well as for the health benefits which they provide (**Chang and Miles, 2004**).
Mushrooms have a high nutritional value, being fairly well off in protein, having the appropriate amount of essential amino acids and fiber but with low fat content. Considerable amounts of vitamins (C, D, E, B_1, B_2, and B_{12}) are provided by edible mushrooms (**Mattila *et al*., 2001**). The edible mushroom can be the best food for diabetic patients and for those who desire to get rid of excess fat since it contains small quantities of carbohydrate and fat (**Deepalakshmi and Mirunalini, 2014**). In the developing countries, oyster mushrooms considerably contribute in overcoming protein deficiency. Also, they are rich in calcium, iron, potassium, copper, zinc, and manganese (**Owaid, 2013**). Particularly, to produce mushroom capsule and extract special strains of dried mushrooms are used. The mushroom is a rich food and in addition to being a satisfying meal, it is unrivaled for flavor (**Alam and Raza, 2001**). Dietary mushrooms offer a broad range of curative properties. Oyster mushroom has important therapeutic properties including antibacterial, antifungal, antiviral, anticancer activities, blood lipid lowering effects and immunity. Mushrooms have also been considered helpful against insomnia, cancer, asthma, diabetes, cholesterol reduction, allergies and stress (**Wang *et al*., 2000**).
Fresh mushrooms being perishable start deterioration instantly within a day after harvest. Because of the extremely delicate nature of fresh mushrooms, they have to be preserved. Many post-harvest procedures can be applied to improve the shelf life. Preserve the quality of mushrooms and enhance storage. This will play a fundamental role in their commercialization (**Gothandapani *et al*., 1997**). Many methods are used for preservation of mushroom but canning is the most commonly implemented methods at a commercial scale. There are many other ways used to increase the shelf life of mushroom like drying, pickling etc. Drying is a reasonably easy and frequently used technique among several methods for the preservation of mushrooms (**Rai *et al*., 2003**). However, drying rate is influenced by many factors which include the thickness of mushroom, moisture diffusivity, temperature and method of drying (**Yapar *et al*., 1990**).
For the diversification of bakery products many nutritionally rich ingredients are added in them (**Sudha *et al*., 2007**). Non-wheat flours which are rich in protein can be incorporated in different products to avert protein deficiency (**Sharma and Chauhan, 2002**). Development and consumption of such therapeutic bakery products like bread would be helpful in raising the nutritional status of the masses. In this light, bread technology probably constitutes one of the oldest technologies known to man (**Selomulyo and Zhou, 2007**). Bread is in fact an important food item considered to be one of the commonly used food products in the world. It is the staple food for many countries and is principally made of hard wheat flour, fat, yeast, salt, sugar and water (**Badifu *et al*., 2005**). This cereal product has low protein content and as such is not a balanced diet because of its low lysine and other essential amino acids (**Agu *et al*., 2010**). Since bread is an important food that is accepted, it can be used as a convenient food item for

protein fortification thereby improving the nutritional health of the people and preventing malnutrition. The premix or composite flour technique plays a significant role in balancing the deficiency of essential nutrients in wheat (**Anjum *et al.*, 2006**). This composite flour technique is actually the process of incorporating other cereals or legumes into wheat flour. As such, locally accessible raw material is therefore used for the preparation of better quality local agricultural food products in an economical way (**Shahzadi**, **2004**). It is from this perspective that while keeping in view the nutritional and medicinal importance of mushroom, this study was carried out to improve the nutritional and functional properties of bread by supplementing wheat flour with mushroom powder. The experimentation involved development of mushroom powder, evaluation of the effect of wheat supplementation with this powder on rheological, physical and chemical properties of bread, and evaluation of organoleptic properties of bread with acceptable level of mushroom powder addition.

MATERIAL AND METHODS

Samples

The research was carried out at National Institute of Food Science and Technology, University of Agriculture, Faisalabad. Oyster mushroom was obtained from Mushroom Lab of Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Remaining raw material was procured from the local market. Mushrooms were dried at a temperature of 45 °C for 2 days. Then mushrooms were ground to powder form.

Proximate analysis

Proximate analysis of wheat flour and mushroom powder were performed according to their respective methods described in AACC (2000).

Rheological analysis

Dough rheology of composite flour prepared with different levels of mushroom powder (0%, 3%, 6%, 9%, 12%, and 15%) was determined by using farinograph and amylograph following the procedure is given in AACC (2000).

Farinographic studies

Wheat flour was examined for physical dough properties by using farinograph according to the procedure outlined in AACC (2000) Method No. 54-21. The farinograms were interpreted for different characteristics such as water absorption, dough development time, dough stability, mixing tolerance index and softening of dough as described below.

Water absorption

Percentage of water required to reach the center of the curve on the 500 Brabender units (BU) lines with the maximum consistency of the dough (peak) is termed as water absorption of that flour sample. For each treatment, water absorption was recorded directly from the burette attached to the farinograph.

Dough development time

This is the time required for the curve to reach its full development or utmost consistency possessing highest peak. High peak values are associated with strong flour, which have long mixing time.

Dough stability

The dough stability was recorded as the time difference between the points where the top of the curve first intersected 500 BU line (Arrival time) and the point where the top of curve left 500 BU line (Departure time).

Mixing tolerance index

The mixing tolerance index was derived in Brabender unit (BU) as the difference from the top of the curve at the peak to top of the curve after 5 minutes from the peak.

Amylograghic studies

Amylogragh characteristics of flour are related to the heating behavior of the starch content of the flour. Alpha-amylase activity was studied for index of biochemical change in BU according to the Method Number 22-12 given in AACC (2000). The straight grade flour sample and blend (flour plus mushroom powder) were run through Brabender-visco. Amylograph equipped with 65 grams capacity bowl to determine properties of dough. A sample of 65 g of flour was combined with 450 ml of distilled water (DW) and mixed to make slurry. The slurry was stirred while being heated in the amylograph, beginning at a temperature of 30 ºC and increasing at a constant rate of 1.5 ºC per minute until the slurry reaches 95 °C. The amylograph recorded the resistance to stirring as a viscosity curve on graph paper. Peak viscosity was the maximum resistance of a heated flour and water slurry to mixing with pins. It was expressed in Brabender Units (BU).

Product development

Wheat flour in the bread was replaced by mushroom powder as described in the treatments (Table 1). T_0 was considered as control.

Table 1 Experimental plan

Treatments	Mushroom powder (%)
T_0	0
T_1	3
T_2	6
T_3	9
T_4	12
T_5	15

Physical analysis of bread

Loaf weight and volume

Loaf weights and volumes were measured 1 hour after removal from the oven. The loaf was weighed using an electronic balance and loaf volume was measured by rapeseed displacement method given in AACC (2000). Each loaf was put in a container and covered with rapeseeds totally fill the container. After that, the loaf was removed and the volume of rapeseed was recorded using the method of **Dubat**. (**2010**). Specific volume was measured by dividing loaf weight to loaf volume.

Texture analysis

The textural study of bread was conducted by using Texture analyzer (Model TA-XT2, Stable Microsystems, Surrey, UK) with a 5kg load cell as described by **Piga *et al.* (2005**). It is an automatic equipment having software attached which gives the measurements of the hardness and resistance of the bread to bend or snap. The Texture Expert program version 4 was used for data analysis. Texture analyzer has three-point bending rig (HDP/3BP) using five-kilogram load cell heavy duty platform (HDP/90). The rig base plate with two adjustable supports that were placed at five cm distance to support the sample. This distance was kept at same for all the samples running. The bread was placed at the central area of the supports. The resistance of the sample to bend is the distance at the point of a break, related to the fracturability of the sample. The sample that breaks at a very short distance has a high fracturability otherwise low fracturability. The display shows force in gram (g) and distance in millimeters (mm). Three loaves of bread of each treatment were analyzed for the hardness (firmness) and fracturability.

Color of bread

The bread crust and crumb color were determined by colorimeter (Neuhaus color test-II, Neotec) according to the method described by Rocha **and Morais** (**2003**) with some modifications. It was first calibrated with the standards (54 CTn for dark and 151 CTn for light). Then the bread sample was ground and filled in Petri plates, to get the optimum reflection of light, emerged by the photocells of the color meter; reading was noted from the display.

Sensory evaluation of bread

The prepared bread loaves were evaluated by a panel of judges (10 panelist) external properties such as crust color, volume, form symmetry, evenness of bake and internal properties like crumb color, grain, aroma, texture, and taste by method of **Land and Shepherd** (**1988**).

Statistical analysis

The data obtained was analyzed statistically in order to compare the effect of different treatments on different parameters of bread. The standard statistical procedure (ANOVA) was applied according to the method described by **Steel *et al*.** (**1997**).

RESULTS AND DISCUSSION

Proximate analysis of wheat flour and mushroom powder

Proximate composition of wheat flour and mushroom powder are shown in Table 2 and Table 3 respectively. In wheat flour, moisture (12.50%), ash (0.35%), crude protein (9.45%), crude fiber (0.30%), crude fat (1.25%) and NFE (76.15%) are present. These results are in close agreement to those obtained by **Ibrahium *et***

***al*. (2014)** who analyzed the effect of replacement of wheat flour with mushroom and sweet potato flour on nutritional composition and sensory characteristics of biscuits and observed moisture ranging from 10.2-12.5%, crude protein 8.23-12.71%, crude fat 1.2-1.8%, crude fiber 0.30-0.76% and ash 0.30-0.66%.

Table 2 Proximate analysis of wheat flour

Characteristics	% age
Moisture	12.50±0.43
Ash	0.35±0.01
Crude protein	9.45±0.03
Crude fiber	0.30±0.01
Crude fat	1.25±0.04
NFE	76.15±2.66

Table 3 Proximate analysis of mushroom powder

Characteristics	%age
Moisture	7.67±0.31
Ash	7.07±0.28
Crude protein	29.60±1.21
Crude fiber	8.33±0.34
Crude fat	1.78±0.07
NFE	45.55±1.86

On its part, mushroom powder contained moisture, ash, crude protein, crude fiber, crude fat and NFE in the range of 7.67±0.31%, 7.07±0.28%, 29.60±1.21%, 8.33±0.34%, 1.78±0.07% and 45.55±1.86% respectively. These values lie within the range mentioned by **Dickeman *et al***., (**2005**). The values of wheat flour and mushroom powder are in accordance with the values mentioned by **Bano and Rajarathnian** (**1988**).

Rheological properties of composite flour

Rheological properties of dough are used as quality indicators for cereal products. There are various instruments, fundamentals and empiricals which can be used for checking the rheology of dough products. Fundamental rheometry describes the physical properties of material over a wide range of strains and rates allowing direct comparison of results obtained by various testing instruments and researchers. For better quality cereal product, it is important to have knowledge about the rheological behavior of wheat flour dough (**Asghar *et al*., 2009**).

Farinographic studies

The farinograph is a sensitive instrument which measures the water absorption and mixing behavior during mixing. It provides information about absorption or amount of water required for dough to reach a definite consistency and secondly a general profile of mixing behavior of dough. **Plyer** (**1988**) has reported that flour from strong wheat varieties had the ability to absorb and retain a large amount of water.

Water absorption

The analysis of variance for water absorption of different composite flour revealed that water absorption was significantly affected by the level of supplementation. It is obvious that water absorption ranged from 56.4 to 66.4 in different flours. The maximum water absorption (66.4%) was observed in 15% mushroom powder supplemented flour while minimum water absorption (56.4%) was observed in 100% wheat flour (control). It is reported that water absorption increases with the increase in protein content. But other factors like starch damage during milling also affect water absorption (**Asghar** et al.**, 2007**). Studies of **Hesham *et al*. (2007)** have concluded that water absorption of flour increases with the addition of mushroom powder and legume flours. The increasing water absorption may be due to the fact that raw and germinated legume and mushroom powder contain more fiber, sugars and higher protein content, which retain more water.

Dough development time

The analysis of variance for dough development time of different composite flour revealed that the dough development time was significantly affected by the level of supplementation. The mean values of dough development time ranged from 1.5 min. to 4.5 min. in different composite flour the highest dough development time (4.5 min) was observed in the 15% mushroom powder supplemented flour, while minimum dough development time was observed in 100% wheat flour (control). The dough development time increased with increase in the level of gluten quality. Dough development time is a sign of protein quality and strength of flour (**Pyler**, **1988**). The results of the current study are in line with the findings of **Rosell *et al*. (2001)** who observed that dough development time increased by adding hydrocolloids in the bread.

Softening of dough

The analysis of variance for softening of dough of different composite flour revealed that the softening of dough was significantly affected by the level of supplementation. The mean values of softening of dough ranged from 255 to 70 BU in different composite flours. In this study, maximum softening of dough was observed in 15% mushroom powder supplemented flour while the minimum softening of dough was observed in 100% wheat flour.

Dough stability

The analysis of variance for dough stability of different composite flour revealed that the dough stability was significantly affected by the level of supplementation. The mean values of dough stability ranged from 1.8 min. to 5.4 min. in different composite flours. An overall increasing trend of dough stability was observed with increase in protein content. The minimum dough stability was observed with mushroom powder supplemented flour 1.8 min while higher dough stability was observed in 100% wheat flour (control). The dough stability is actually tolerance of flour to over or under mixing. It is a primary index of flour quality and is one of the most significant determinations made by farinograph **(Pyler, 1988).** It is clear from the study of **Hesham *et al*.** (**2007**) that dough stability decreased as the concentration of mushroom powder increased.

Mixing tolerance index

The analysis of variance for mixing tolerance index of different composite flours revealed that the mixing tolerance index was significantly affected by the level of supplementation. The mean values of mixing tolerance index ranged from 52 to 75 BU in different composite flour. An overall increasing trend of mixing tolerance index was observed with increase in protein content. The highest mixing tolerance index (75 BU) was observed in 15% mushroom powder supplemented flour while lowest mixing tolerance index (52 BU) was observed in 100% wheat flour (control).
A study of **Mueen Ud Din** (**2009**) related to mixing tolerance index showed that mixing tolerance index varied from 21 to 64 BU in straight grade flours. **Sudha *et al***. (**2007**) reported that by the addition of wheat bran and rice bran blend, mixing tolerance was increased significantly. The results of this study were in accordance with the result of **Lee *et al.* 2000**. Moreover, **Oh and Kim** (**2002**) suggested that by the addition of green tea powder, mixing tolerance index is significantly increased.

Amylographic studies

The amylograph is related to the starch content of the flour and its behavior during heating. Amylograph checks the alpha amylase activity during gelation period of starch. In the present study, wheat flour was substituted with mushroom powder due to which amylase activity decreased. Analysis of variance related to peak viscosity shown in Table 4 showed mean values of peak viscosity of different composite flour. It is clear from the table that mushroom powder has a significant effect on wheat flour. The peak viscosity was observed and it was noted that peak viscosity increased from 820 to 1700 BU. It showed that as the level of fiber increased, peak viscosity started to decreased.

Table 4 Effect of mushroom powder on peak viscosity of different composite flour

Treatment	Peak viscosity (BU)
T_0	820^d
T_1	1700^a
T_2	1659^{ab}
T_3	1635^{bc}
T_4	1610^{bc}
T_5	1595^c

Legend: T_0 = Control (100% Wheat flour), T_1 = 3% mushroom powder supplementation, T_2 = 6% mushroom powder supplementation, T_3 = 9% mushroom powder supplementation, T_4 = 12% mushroom powder supplementation, T_5 = 15% mushroom powder supplementation.

Sudha *et al*. (**2007**) studied the effect of apple pomace as a source of dietary fiber on the rheology of cake. They concluded that amylograph studies showed decrease in viscosity of peak and cold paste viscosity from 950-730 BU and from 1760-970 BU, respectively. The studies of **Sharma *et al*. (1999)** were related to the effect of cowpea flour and wheat flour blend on rheological and baking properties. They showed that peak viscosity decreased with increase in mushroom powder level. That may be due to less swelling and gelatinization of starch due to protein molecules around them.

Analysis of Bread

Physical analysis of bread

Loaf weight and volume (Rapeseed displacement method)

The results indicated that loaf volume of bread was affected significantly by different levels of mushroom powder. It is obvious from results that loaf volume was higher for the bread prepared from the non-supplemented wheat flour as compared to the supplemented wheat flour. The mean values for loaf volume of bread prepared from the different composite flour samples are showed in Table 5. The results revealed that the maximum loaf volume (575 cm^3) was obtained from the bread produced by 100% wheat flour (control) followed by the 3% mushroom powder supplemented bread (555 cm^3) while the minimum loaf volume (450 cm^3) was found in the 15% mushroom powder supplemented bread. The decrease in loaf volume of the bread may be attributed to the reduction in the wheat structure forming proteins and a low ability of the dough to entrap air. The protein quantity, alpha amylase activity, and damaged starch might have a significant effect on bread volume and baking quality for different composite flours (**Butt *et al*., 1997**).

Table 5 Effect of mushroom powder on physical characteristics of mushroom powder supplemented bread

Treatment	Volume (cm^3)	Weight (g)	Specific loaf volume (cm^3/g)
T_0	575.00^a	160^f	3.59^a
T_1	555.00^b	170^e	3.26^b
T_2	530.00^c	180^d	2.94^c
T_3	500.00^d	205^c	2.43^d
T_4	474.67^e	215^b	2.20^e
T_5	450.00^f	225^a	2.00^f

Also, **Vittadini and Vodovotz** (**2003**) reported that soy flour added bread has lower loaf volume as compared to the 100% wheat flour bread. Results regarding the weight of loaf bread are shown in Table5 .Values of loaf weight increased from 160 g to 225 g by an increase in supplementation level of mushroom powder. Specific loaf volume is measured by dividing the volume of bread loaf to the weight of bread loaf. The results revealed that specific volume is significantly affected by the addition of mushroom powder. Mean values related to specific loaf volume are shown in Table 5. According to the results, specific volume varies from 3.59 to 2.00 cm^3/g. The highest value was attained by 100 % wheat flour but bread containing 15 % mushroom powder had the lowest value of specific volume. It is clear from the studies of Okafor ***et al***. (**2012**) that values of specific loaf volume decreased from 3.73 to 1.98 cc/g by the addition of mushroom powder.

Textural characteristics of bread

Bakery products have a characteristic shape and definite texture that is accepted by the consumers. Any significant deviation from the optimal texture characteristics of the product can be considered as a reduction in quality. Texture has a significant influence on consumer's perception of a good bread quality. The most important attributes of bread include hardness and springiness, and further parameters such as chewiness, gumminess, and cohesiveness can be taken into account as well. Hardness is defined as the force required for biting bread samples, springiness is the degree to which a sample returns to its original thickness after compression. Cohesiveness is a characteristic of mastication, gumminess depends on cohesiveness and hardness; chewiness depends on springiness and gumminess (**Meretei *et al*., 2003**).

Bread hardness by compression test

The analysis of variance results for bread hardness prepared form different composite flours are presented in **Table 6**. The results indicate that the bread hardness varied and was highly significant among different composite flours. The results showed that bread hardness ranged from 224 to 1020 g among the various bread. The highest bread hardness (1020 g) was recorded from the bread prepared with 15% mushroom powder. The lowest hardness (224 g) was recorded with the bread produced by 100% wheat flour. Similar textural and crumb grain profiles have been stated previously by means of sensorial and instrumental studies of bread (**Shittu *et al*., 2007**).

Penetration test for bread fracturability

The results indicate that bread fracturability varied significantly among different composite flours. The fracturability of bread increased as the level of mushroom powder increased in bread. The mean values presented in Table 6 revealed that bread fracturability ranged from 37.02 to 35.09 mm among bread of various mushroom powder supplementation.

Table 6 Effect of mushroom powder on textural characteristics of mushroom powder supplemented bread

Treatments	Bread hardness (g)	Bread fructurability (mm)
T_0	224^f	35.09^c
T_1	280^e	35.16^{bc}
T_2	440^d	35.16^{bc}
T_3	552^c	36.38^{ab}
T_4	860^b	36.74^a
T_5	1020^a	37.02^a

Color

The color of bread was determined with the help of Color meter II as described by **Rocha and Morais** (**2003**). The color of the bread was determined by placing the bread under photocell. The colorimeter was calibrated by using standards (54CTn for dark and 165CTn for light). It is evident that the color value differed significantly due to differences in supplementation level of mushroom powder in wheat flour. The mean values of the color of bread prepared from composite flours given in Table 7 indicated that the bread from control (100% wheat flour) had the maximum color value (162CTn) and its value decreased gradually as the level of mushroom powder supplementation increased in wheat flour. The darker color was due to mushroom powder supplementation. The bread prepared from 15% supplementation of mushroom powder in wheat flour got the minimum color value (135CTn).

Table 7 Effect of mushroom powder supplementation on color score of bread

Treatments	Color (CTn)
T_0	162^a
T_1	152^b
T_2	142^c
T_3	141c
T_4	140^{cd}
T_5	135^d

Sensory evaluation of bread

Sensory evaluation is an important criterion for quality assessment in new product development and to meet the consumer requirements. Any new product must give satisfaction and pleasure to the consumers if it has to be a part of their eating habits. For this reason, the bread prepared from wheat flour supplemented with mushroom powder was evaluated for various sensory attributes. The sensory evaluation of bread for various attributes such as volume, color, the symmetry of form, evenness of bake, the character of crust, grain, the color of crumb, aroma, taste and texture was carried out. The product was evaluated by a panel of judges and the results are described below.

Volume

The results revealed that the scores assigned to a volume of bread were affected significantly by the level of mushroom powder supplementation. It is evident from the results which are shown in Table 8 that there was a significant decrease in assigning scores to bread as the level of mushroom powder supplementation increased in flour. The highest volume score (7.85) was gained by bread prepared from control (100%) followed by 3% mushroom powder (6.71) and 6% mushroom powder supplemented wheat flour (6). The lowest volume scores (3.20) was obtained from the bread prepared from 15% mushroom powder supplemented composite flour. The decrease in volume was observed with increase in the level of mushroom powder supplementation.

Replacement of wheat flour with non-wheat flour had a certain negative effect on bread volume. **Iqbal** (**2007**) also found that incorporation of cowpea flour in wheat flour significantly reduced the score for the volume of bread. **Mcwalter *et al*. (2004)** and **Hesahm *et al***. (**2007**) also reported that incorporation of cowpea flour in dough had a certain negative effect on bread volume.

Color of crust

The scores assigned to crust color of bread were significantly affected by the supplementation of mushroom powder. It is obvious from results that color scores for bread differ significantly due to the different treatments. The interaction of treatments showed a significant effect on the color score of the bread. A significant decrease in color score was observed with increase in the level of supplementation of mushroom powder. The effect of blending, on the bread color was more pronounced when higher concentrations of mushroom powder were used. The mean score for the color of the bread prepared from the mushroom powder supplemented composite flour samples are shown in Table 8. It is obvious from results that bread prepared from the flour containing 15% mushroom powder got the lowest color score (4.0) followed by the 12%

mushroom powder (4.28). The highest score (8.14) was obtained by control followed by 2% mushroom powder. It was observed that decrease in color score of mushroom powder supplemented bread decreased proportionally with the increase in the level of mushroom powder. Crust color of the bread was light brown which darkened progressively with the increasing level of mushroom powder. The darkened color of crust may be due to the Maillard reaction taking place during baking of loaves, due to high lysine contents. This corroborates with **Hussain** (**2004**) who found that there was a progressive decrease in assigning the scores to crust color of bread as the wheat flour was replaced by non-wheat flour. **Okafor *et al.* (2012)** also reported that scores for color of crust decreased by increasing the level of mushroom powder form control (100% wheat flour) to T_5 (15 % mushroom powder)

Symmetry of form

The results for the symmetry of form of bread prepared from different composite flours indicated significant differences among bread prepared from mushroom powder supplemented bread with respect to their symmetry of form. The mean scores assigned to the symmetry of form of bread prepared from mushroom powder supplemented bread are shown in Table 8. It is evident from the results that bread prepared from 100% wheat flour got significantly the highest scores (3) but non-significantly different from each other for their symmetry of form from the judges. The lowest (1.0) scores for symmetry of form were obtained from bread prepared with 15% mushroom powder supplemented wheat flour. **Iqbal** (2007) also found that incorporation of cowpea flour in wheat flour significantly reduced the score for symmetry of form of bread.

Evenness of bake

It is obvious from the results that evenness of bake differs significantly due to different treatments. The mean squares concerning scores allocated to evenness of bake of bread prepared from different mushroom powder supplemented wheat flours are presented in Table 8. The results point out that score for the evenness of bake of bread ranged from 2.71 to 1.42. The highest score (2.71) for the evenness of bake was allocated to the bread prepared from the 100% wheat flour (control). The bread prepared from the 15% mushroom powder supplemented wheat flour obtained the lowest score (1.42) for the evenness of the bake. **Chavan *et al*. (1991)** observed that the score assigned to evenness of bake decreased as the supplementation level of peanut flour increased. **Hussain** (**2004**) found that there was a progressive decrease in assigning the scores to evenness of bread as the wheat flour was replaced by non-wheat flour.

Character of crust

The scores assigned to the character of crust were significantly affected by the addition of mushroom powder in wheat flour. The mean scores assigned to the crust character of bread prepared from mushroom powder supplemented wheat flour are given in Table 8. The character of crust scores was allocated maximum (2.85) to bread prepared from 3% mushroom powder supplemented in wheat flour followed by bread prepared from 6% mushroom powder supplemented wheat flour. **Chavan *et al*.** (**1991**) observed that the score assigned to crust character of bread decreased as the supplementation level of peanut flour increased. **Hussain** (**2004**) equally reported that the scores assigned to the character of crust were significantly reduced by the addition of flaxseed flour in straight grade flour.

Color of crumb

The results indicate that mushroom powder supplementation level significantly affected the crumb color of the bread. The scores assigned by the panelists to the crumb color of bread prepared with different levels of mushroom powder supplementation in wheat flour (Table 8) indicated that bread prepared without mushroom powder supplementation (100% wheat flour) got significantly the highest scores (8.14) for crumb color while the bread prepared with 15% mushroom powder supplemented wheat flour were ranked at the bottom (3.50) by the judges. It is also evident from the results that bread prepared from 3% and 6% mushroom powder supplemented wheat flour had close values. These results are similar to the finding of **Okafor *et al.* (2012)** who observed that scores assigned to the crumb color of bread decreased as the level of mushroom powder increased. **Chavan *et al.* (1991)** observed that the score assigned to the color of the crumb of bread decreased as the supplementation level of peanut flour increased. The darkening of color is due to the Maillard reaction.

Table 8 Effect of mushroom powder on external characteristics of mushroom powder supplemented bread

Treatment	Volume	Color of crust	Symmetry of form	Evenness of bake	Character of crust	Color of crumb
T_0	7.85^a	8.14^a	3.00^a	2.14^b	2.71^b	8.14a
T_1	6.71^b	7.85^b	2.42^b	2.14^b	2.85^a	7.71b
T_2	6.00^c	7.00^c	2.14^c	2.71^a	2.71^b	7.00c
T_3	5.42^d	5.71^d	2.00^d	2.00^c	2.00^c	6.00d
T_4	4.42^e	4.28^e	1.14^e	1.71^d	1.71^d	4.50e
T_5	3.20^f	4.00^f	1.00^f	1.42^e	1.42^e	3.50f

Internal characteristics

Grain

The statistical analysis indicated that scores given to grain of bread were affected significantly by the levels of mushroom powder supplementation in wheat flour. The results presented in Table 9 indicated that there was a progressive decrease in scores assigned to the grain of bread as the supplementation level of mushroom powder increased. The highest scores (9.71) were given to grain of bread prepared from control (100% wheat flour) followed by bread prepared from 3% mushroom powder (8.71) and 6% mushroom powder (7.50) supplemented wheat flour. The lowest scores to grain (4.00) were assigned to the bread prepared from 15% mushroom powder wheat flour. These observations are in line with those made by Hussian (**2004**) who observed that scores given to grain of bread were affected significantly by the levels of flaxseed supplementation in straight grade flour. **Hesham *et al*.** (**2007**) also found that mushroom powder and legume flour deteriorates the crumb grain in proportion to quantity of flour used to replace the wheat flour.

Table 9 Effect of mushroom powder on internal characteristics of mushroom powder supplemented bread

Treatment	Grain	Aroma	Texture	Taste
T_0	7.42^c	7.50^a	8.85^d	13.14^a
T_1	8.71^b	7.42^a	11.00^b	11.71^b
T_2	9.71^a	7.28^{ab}	10.71^b	10.58^c
T_3	7.50^c	7.14^b	11.71^a	10.57^c
T_4	5.50^d	5.71^c	9.28^c	8.00^d
T_5	4.00^e	5.00^d	7.14^e	7.28^e

Legend: T_0 = Control (100% Wheat flour), T_1 = 3% mushroom powder supplementation, T_2 = 6% mushroom powder supplementation, T_3 = 9% mushroom powder supplementation, T_4 = 12% mushroom powder supplementation, T_5 = 15% mushroom powder supplementation

Aroma

The results pertaining to analysis of variance relating to the aroma of bread prepared from different levels of mushroom powder supplementation showed that supplementation levels significantly affected the scores given to aroma of bread. The scores assigned to the aroma of different breads presented in Table 9 showed that bread prepared from 100% wheat flour got statistically the highest scores (7.50) for aroma followed by bread from 3% mushroom powder supplemented wheat flour (7.42) whereas the minimum aroma scores were assigned to the bread prepared from 15% mushroom powder supplemented wheat flour. **Hussain** (**2004**) observed that scores given to aroma of bread were affected significantly by the levels of flaxseed supplementation in straight grade flour.

Texture

Sensory demonstration of food products structure in terms of their response to stress by senses in the muscles of hands, fingers or tongue in the tactical nerves in the surface of the skin is called texture **(Dah, 2010).** It is considered a quality attribute associated with product freshness. Food texture may be extremely important because it acts as an indicator of food quality. The analysis of variance regarding the texture of bread prepared from different composite flours is given in Table 9. The results indicated that scores given to texture of bread differed significantly due to differences in supplementation level of mushroom powder in wheat flour. Results proved that the bread from 100% wheat flour got the maximum scores for texture (11.71) and the scores decreased gradually as the supplementation level of mushroom powder increased in wheat flour. The bread prepared from 15% supplementation of mushroom powder in wheat flour obtained the lowest scores (7.14) by the judges for texture. **Hussain (2004)** found that there was a progressive decrease in assigning the scores to evenness of bread as the wheat flour was replaced by non-wheat flour. **Ory and Conkerton** (**1983**) also observed that the incorporation of peanut flour in wheat flour significantly affect the texture of bread. **Chavan *et al*. (1991)** observed that the score assigning to evenness of bake decreased as the supplementation level of peanut flour increased.

Taste

The major component of the flavor detected by the taste buds of the tongue, mouth membrane and influenced by the texture, flavor, and composite of food products is called taste. It is considered the most important attribute regarding the quality of any food product. **(Miyaki *et al*., 2015).** The statistical results for scores allocated to the taste of the bread samples prepared from different mushroom powder wheat flour blends showed a significant effect of level of mushroom powder supplementation. The results showed that the bread prepared from 100% wheat flour got the highest scores (13.14) for taste by the panelists. It is clear from the results that bread prepared from 10% mushroom powder supplemented wheat flour were graded at the bottom with respect to taste scores. The results in Table 9 further exposed that bread prepared from 6% (10.58) and 9% mushroom powder (10.57) supplemented wheat flour acquired non-significantly different scores for taste. There was a decline in assigning the scores to bread by increasing the level of mushroom powder supplementation in wheat flour. **Okafor *et al*. (2012)** reported that scores allocated to the taste of bread decreased as the level of mushroom powder supplementation increased. **Hussain** (**2004**) also observed that scores given to taste of bread were affected significantly by the levels of flaxseed supplementation in straight grade flour.

CONCLUSION

The results of the present study suggest that mushroom powder may be supplemented up to 6% in wheat flour to get acceptable bread with improved protein content. The blending of mushroom powder in wheat flour can help to improve the nutritional status of the masses in the under-developed and developing countries.

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