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REGULAR ARTICLE

Development and quality evaluation of mushroom (*pleurotussajor-caju*) enriched biscuits

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ABSTRACT

Supplementation of foods is of current interest because of increasing nutritional awareness among consumers. Biscuits can be easily fortified with protein rich flour to provide convenient foods, in order to supplement protein in the diet and nutrition. As such mushroom is commonly consumed by the public and more relished, the present investigation was therefore undertaken to explore the possibilities of using mushroom powder (MF) in biscuits without impairing their acceptability. Nutrient composition and sensory investigation of biscuits incorporated with various levels of oyster mushroom (*Pleurotussajor-caju*, PSC) powder were studied. The biscuits were formulated with 0, 5, 10 or 15% of PSC powder to replace wheat flour (WF). The results showed that biscuits formulated with 15% PSC powder significantly ($p < 0.05$) increased the protein content (13.45%) in comparison to control (12.15%). Meanwhile, the addition of PSC powder in biscuits did not affect the fat content remarkably compared with control biscuits. Both biscuits containing 10% and 15% PSC powder recorded 4.92 g/100 g and 5.07g/100 g total dietary fiber respectively that significantly ($p<0.05$) higher than to control biscuits (4.47 g/100 g). There was a non significant relation found in Bulk Density (g/cm^3), Spread Ratio (g/cm) and Spread Factor in5, 10 and 15% mushroom biscuits compared to control biscuits. In the sensory evaluation, biscuits incorporated with 10% PSC powder had the highest scores for all sensory attributes except for color and appearance. The present study suggested that incorporation of PSC powder up to 10% to replace wheat flour increased concentration of protein, dietary fiber, ash and lowering carbohydrate in biscuits.

Keywords: Biscuits; Mushroom; Nutrient composition; Supplementation; Sensory evaluation

INTRODUCTION

Baking technique is probably the earliest and oldest of all other techniques and is still going steady over food processing field. Bakery products have played a key role in the development of mankind, being a principal source of convenience, variety and a healthy nutrition component to modern lifestyles. Bakery biscuits are very popular, ready to eat, convenient, inexpensive and also an important product in human diet and are usually eaten with tea and are also used as weaning food for infants. It is also used as a snack in school for the school going children who are often underweight. It may be used as a nutrient supplement during emergency situation (Baljeet et al., 2010). Not only long shelf-life of biscuits makes large scale production and distribution possible but also good eating quality makes biscuits more attractive for protein fortification and other nutritional improvements (Hooda and Jood, 2005). The primary ingredient used for the production of biscuits is wheat flour which is deficient in several nutrients including vitamins, minerals as well dietary fiber (Ayo and Nkama, 2003). Wheat flour also lacks essential amino acids such as lysine, tryptophan (Awan et al., 1991). Enrichment of biscuits with supplements like protein and vitamins is of current interest because of nutritional awareness of consumers. Hence partial replacements of wheat flour with other ingredients to make functional food are in high demand. Edible mushrooms formerly called the "food of the gods." Edible mushrooms still treated as a garnish or delicacy can be taken regularly as part of the human diet or as functional food. Mushrooms have been consumed and appreciated for their flavor, economical and ecological values and medical properties for many years (Sanchez, 2010). Although mushroom contains approximately 90% water, but its protein and amino acids content, low fat and 9-group vitamins and a wide spectrum of mineral substances it represents a high-quality source of biological substances for human

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nutrition (Strmiskova et al., 1992). Mushrooms contain (dry basis) more than 25% protein, less than 3% crude fat and almost 50% of total carbohydrate (Kotwaliwale et al., 2007). Mushrooms are considered to be a healthy diet because it is low in calorie, sodium, fat and cholesterol. So as to mushrooms form an important constituent of a diet for a population suffering from atherosclerosis (Dunkwal et al., 2007). It also contains considerable amount of dietary fiber and β-glucan, vitamin D, vitamin B complex and other useful nutrients. Mushrooms have also been associated with many pharmacological properties by both western and eastern medicine. The functions of mushroom include reducing blood cholesterol (Bobek et al., 1997), lowering blood pressure, strengthening the immune system against diseases, combating tumors and improving liver function (Reguła and Siwulski, 2007). Previous experimental evidence suggests oyster mushroom (*Pleurotussajor-caju)* through its active ingredients affect the renin-angiotensin system (Chang, 1996). Mushrooms have been used as medicinal materials from 100 years ago (Wasser et al., 1999). Historically starting from 1970s, Japanese researchers found antitumour compounds in some mushroom species were polysaccharides whose basic structure was beta glucan. These polysaccharides were different from the usually used carcinostatic effects were based on the immunological enhancement in host. The modern science of nutrition has moved to understanding the physiological and genetic mechanisms by which the diet and individual food components influence health and diseases. Majority of processed foods do provide some nutritional value. Healthy developed processed foods sometimes provide an acceptable nutritional components and awesomeness in sensorial quality to consumers. Some people even prefer the flavor developed from processed foods as compared to fresh products. Therefore the aim of the present study was to develop a novel variety of biscuits enriched with addition of mushroom powder and investigate the proximate compositions and sensory acceptance of mushroom enriched biscuits.

MATERIALS AND METHODS

Place of experiment

The study was conducted in the laboratories of Masafi Bread and Biscuits Industry, Dimond Biscuits Limited and in the laboratory of Food Technology and Nutritional Science Department, Mawlana Bhashani Science and Technology University during the period July 2013 to January 2014.

Raw materials

Wheat flour, salt, sugar, palm oil, sugar syrup, ammonium bicarbonate, sodium bicarbonate, lecithin and other general ingredients were procured from the local market.

Procurement of mushroom

Fresh edible mushrooms (*Pleurotussajor-caju)* were collected from the local market. Immediately after procurement, non-edible portions and unwanted wastes or particles (e.g., soil, portion of compost where they were grown, spoiled portion of mushrooms, etc.) were separated and removed. Then mushroom were cleaned with clean water.

Preparation of mushroom powder

At first the fresh mushroom were cleaned with water and then chopped into small pieces. Then the chopped mushrooms were blanched in hot water containing 3% salt and 0.01% citric acid (100°C) for 3 minutes. After drained off the water mushrooms were spread in trays and dried in sunlight at 33±2°C up to 9-10% moisture level for about 48 hours. Then the mushroom were cooled in room temperature, and then ground into powder in a grinder. The mushroom powder was then sieved and packaged in polythene bags and stored at room temperature for further use in the preparation of biscuits.

Preparation of composite flours

The composite flour was prepared by using certain proportions of wheat flour and mushroom powder according to the recipe as shown in Table-1.

Manufacturing process of biscuits

Wheat flour and mushroom powder blends were prepared in the ratio of 100:0, 95:5, 90:10 and 85:15 respectively (Table-2). All dry ingredients were sieved through 65 mesh screen and were mixed together to obtain auniform blend. Fat for shortening, sugar and lecithin were mixed together to obtainsweetened shortening cream. Then slowly mixed dry flour was added to shortening cream withaddition of water to prepare dough. The dough was prepared by manual kneading of all the dryand liquid ingredients to attain uniformity with desirable visco-elastic characteristics. When dough was ready it was kept for 10-15 minutes as it is and then used for sheeting, sheets weremade by rolling balls of dough on wooden platform. These sheets were cut by hand operatedmetal dye, arranged on an appropriate fat (butter, margarine) coated tray and were kept forbaking. Baking takes place in three successive stages in electric oven. In the beginning structuralchanges take place due to heating of dough. In second stage greatest loss of moisture take place.In third stage the color of biscuits changes to typical light brown color of finished biscuits. Eachlot requires 20 minutes at 160^0 C for baking. Then the baked biscuits were cooled to roomtemperature and packed and stored in dry airtight container at 25^0C.

Proximate analysis

All samples (wheat flour, fresh mushroom, mushroom powder and biscuits) were analyzed for chemical

Table 1: Recipe of control and mushroom biscuits

Ingredients	Control (gm)	5% MF (gm)	10% MF (gm)	15% MF (gm)
Wheat flour	100	95	90	85
Mushroom powder	00	5	10	15
Palm oil	16	16	16	16
Sugar	14.80	14.80	14.80	14.80
Sugar syrup	2.50	2.50	2.50	2.50
Ammonium bicarbonate	0.40	0.40	0.40	0.40
Sodium bi carbonate	0.10	0.10	0.10	0.10
Salt	0.62	0.62	0.62	0.62
Lecithin	0.20	0.20	0.20	0.20

Table 2: Development of mushroom biscuits

Trials	MF:WF	Descriptive profile of biscuits
Control	0:100	Golden brown, evenly baked, attractive, well spread, light and crisp, pleasant baked aroma and flavor, smooth in mouth feel
5% MF	5:95	Brown, evenly baked, attractive, well spread, light and crisp, pleasant baked aroma and flavor, acceptable taste
10% MF	10:90	Brown, evenly baked, attractive, medium spread, slightly compact, pleasant baked aroma and flavor, acceptable taste
15% MF	15:85	Comparatively less brown, evenly baked, attractive, less spread, slightly compact, pleasant baked aroma and flavor, slight coarse mouth feel

composition (moisture, protein, fiber, fat, ash and carbohydrate) content by using the Association of Official Analytical Chemists Method (AOAC, 1996). The moisture content was determined by oven drying methods. The crude protein content of the samples was estimated by the macro Kjeldahl method. The crude fat was determined by extracting a known weight of samples with petroleum ether, using a Soxhlet apparatus. The ash content was determined by incineration method. Total carbohydrates were calculated by the difference: total carbohydrates = 100 – (g moisture + g protein + g fat + g ash).

Analysis of functional properties of mushroom powder

Water retention of mushroom powder was determined by modification ofMcConnell et al. (1974) methods. At first, 2g of mushroom powder was soaked in 20 ml of distilled water for 12 h and then centrifuged at 3,000 rpm for 20 minutes. The volume of water separated after centrifugation was measured and water retention was calculated using following formula

Water retention (ml/g) = Water retained (ml)/Weight of sample (g)

[Water retained (ml) = (Volume of water added 20 ml - Volume of water obtained after centrifugation)] (McConnell et al., 1974).

For determination of fat absorption capacity 1g of mushroom flour was taken in a centrifuge tube and weight was recorded. Then 6 ml of refined oil was added to the flour and centrifuged at 4000 rpm for 25 min. Free oil was decanted and weight of the centrifuge tube was noted (Sosulki, 1962).

$$\% \text{ Fat absorption capacity} = \frac{\text{Weight of sample after centrifugation - Weight of sample before centrifugation}}{\text{Weight of original sample taken}} \times 100$$

For determination of swelling index 5 g dehydrated sample was soaked in 100 ml of distilled water, kept overnight at room temperature (20-30 8 C). Then swelling index was calculated using the following formula according to the method given by Rasper (1979).

Swelling index (ml/g) = Change in volume (ml)/Amount of sample (g)

For per cent solubility of mushroom powder, the dried petriplate was weighed (W4) and 10ml of supernatant (VA) was pipetted into the petriplate. Then it was dried at 105°C in a hot air oven till constant weight was attained and cooled in a descicator and again weighed the petriplatewith dry solids (W5). W1 = Weight of mushroom flour sample, VE = Volume of water added. The per cent solubility of the supernatant was calculated by,

$$\% \text{ solubility} = \frac{(W5 - W4)}{VA} \times \frac{100}{W1}$$

Dispersibility was measured by placing 10 gm of mushroom flour sample in 100 ml stoppered measuring cylinder. Distilled water added to the volume of 100 ml, stirred vigorously and allowed to settle for 3 hours. The volume of settled particles was subtracted from 100 and the difference was recorded as percentage dispersibility. Cold and hot paste viscosities of mushroom flour was tested at 5 and 10 per cent slurry concentrations (100 ml) using Viscometer at 100 rpm with spindle number two.

Physical characteristics of biscuits

Assessment of physical characteristics of biscuits is an important aspect which determines the consumer acceptability. Physical characteristics of the biscuits were studied employing standard procedures (Anon., 1983). Average weight of six biscuits was recorded in grams using electronic balance. Biscuits volume was measured by grain amaranth seed displacement method. Average thickness of biscuits was measured by stacking six biscuits and measuring height to nearest mm. Width of biscuits was measured by laying six biscuits to edge, measuring nearest mm. And then Bulk density, Spread ratio and

Table 3: Chemical composition of raw materials

Sample	(% ±SD)					
	Moisture	Protein	Fiber	Fat	Ash	Carbohydrate
Wheat flour	12.55±0.64	10.50±0.32	0.60±0.10	1.20±0.18	0.85±0.12	74.3±1.54
Fresh mushroom	87.97±2.28	5.14±0.20	2.75±0.18	0.97±0.12	1.4±0.18	1.77±0.42
Mushroom flour	12.12±0.78	24.51±0.62	12.0±1.14	2.43±0.16	5.54±0.80	43.4±2.50

spread factor of biscuits was calculated by using formula given by Anon (1983).

Sensory evaluation

Sensory evaluation for the color, texture, taste, odor and overall acceptability were done in order to determine consumer acceptability. A numerical hedonic scale ranging from 1 to 9 (1 is Excellent and 9 for Very poor) was used for sensory evaluation (Larmond, 1977). Ten experienced judges from Masafi Bread and Biscuits Industry and Dimond Biscuits Limited were participated in the test.

Statistical analysis

All analyses were performed in triplicate. The differences between various levels of supplementation in biscuits were obtained by using statistically analysis according to the methods described by Steel and Torrie (1980). The comparisons were carried out by SPSS (16) programme.

RESULTS AND DISCUSSION

Chemical composition of raw materials

The raw materials, i.e., wheat flour, fresh mushroom and mushroom powder were analyzed for proximate composition andthe data are presented in Table-3. Wheat flourcontained 12.55% moisture, 10.50% protein, 0.60% crude fiber, 1.20% fat and 0.85%ash. Owing to the extractionof bran and germ from whole wheat flour, it contains lesser amount of protein, fiber, fat and ash. This table also represents that fresh mushroom contained more than 87% moisture, 5.14% protein, 2.75% fiber and 1.40% ash. The composition of fresh mushrooms was found more or less similar to those reported by Gupta and Sarma (2004). But analysis of mushroom powder, there was a great modification in nutrient content was found. Mushroom powder was richer in crude protein, crude fiber and ash as compared to WF. Average protein content in the mushroom powder was 24.51% protein, 12.00% crude fiber, 5.54% ash.

The Table-4 shows the water retention capacity of mushroom powder prepared from fresh mushroom was enormous (2.40 ml/g) as better water retention capacity is directly associated with the amount and type of fiber, protein content and damaged starch present in the dehydrated flour (Rasper, 1979). The mean value of oil absorption capacity of

Table 4: Functional properties of mushroom powder

Properties	Mushroom powder
Water retention (ml/g±SD)	2.40±0.20
Oil absorption capacity (%±SD)	450±0.60
Dispersibility (%±SD)	31.00±0.20
Swelling index (ml/g±SD)	0.46±0.02
Per cent solubility (%±SD)	1.90±0.20
Viscosity at different concentration	
Hot slurry (90°C) (%)	
5	20.2
10	40.6
Cold paste (25°C) (%)	
5	28.1
10	52.8

the mushroom powder recorded 450 %. The dispersibility of the mushroom powder noted 31 %. The swelling index of the mushroom powder was recorded as 0.46 ml/g. The swelling index of mushroom powder under study was more or less similar to those reported by Dunkwal et al (2007). They reported the swelling index of mushroom powder was 0.40 ml/g when using oven drying method. The percent solubility of the mushroom fpowder noted 1.90 per cent. The cooked paste viscosity of 5 % mushroom powder paste got lower value (28.10 %) than 10 % paste (52.40 %) at ambient temperature. Similar observations were also established at hot temperature (90°c); the 5 % slurry was less viscous (20.20 %) than the 10 per cent (40.60 %) slurry.

Storage quality of mushroom powder

In the Fig. 1 it is clearly indicates that, there was an increase in the moisture content from the initial value (12.12 %) to 12.34, 12.45, 12.48, 12.60, 12.64 and 12.75 per cent in ambient temperature and 12.18, 12.25, 12.30, 12.34, 12.42 and 12.44 % in refrigerated conditions, respectively with the intervals of a month. Peak increase in the moisture level was found at 1st (12.34%), 5th (12.64 %) and 6th (12.75 %) months of storage at ambient temperature. whereas, a gradual increase in moisture level was noticed in the samples stored under refrigerated condition.

Proximate composition of mushroom biscuits

The protein content of mushroom biscuits prepared from composite flour of wheat and mushroom powder ranged from 12.80 to 13.45% (Table-5). The protein content increased proportionally with replacement of mushroom powder to wheat flour in biscuits formulations. Mushroom

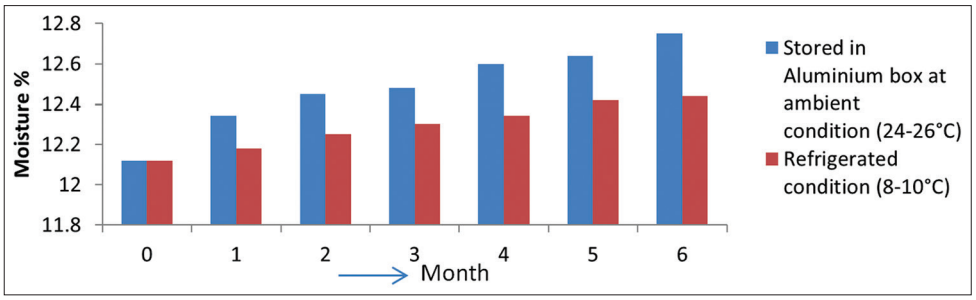

Fig 1. Moisture content (%) of stored mushroom powder.

Table 5: Proximate composition of normal and mushroom biscuits

Samples	(%±SD)					
	Moisture	Protein	Fat	Ash	Crude fiber	Carbohydrate
Control	3.83±1.40	12.15±1.32	5.44±0.30	3.49±0.64	4.47±1.12	70.62±1.86
5% MF	4.52±0.98	12.80±1.48	5.65±0.52	3.61±0.40	4.71±0.68	68.71±2.14
10% MF	4.44±0.22	13.25±1.34	5.81±0.44	3.85±0.36	4.92±0.66*	67.73±1.12
15% MF	4.51±0.48	13.45±1.50*	5.89±1.10	4.13±0.50	5.07±0.22*	66.95±1.56

*p<0.05 when compared control biscuits to 5%, 10% and 15% MF biscuits

biscuits containing 15% mushroom powder significantly ($p< 0.05$) increase the protein content (13.45%) than to control biscuits (12.15%). These findings are similar with previous studies conducted by Ory and Conkerton (1983) on supplementation of bakery foods with high protein peanut flour. This table also shows that the addition of 5% and 10% mushroom powder does not affect the fat content (5.65% and 5.81%) compared with control (5.44%). However, the addition of mushroom powder up to 15% slightly increased the fat content (5.89%) in the finished biscuits product. This slight elevation of fat content may be due to the fact that the original mushroom powder used in biscuits formulation contains 2.43% fat (Table 1). In the meantime, although total ash content was found to increase in line with the mushroom powder level in biscuits formulations, it was not remarkable. All biscuits recorded total ash content ranging from 3.61% - 4.13%. Mushroom flour enhanced nutritional values in terms of dietary fiber by 4.71, 4.92 and 5.07% at the level of 5, 10 and 15 % mushroom flour incorporation but decrease carbohydrate content over control biscuits.

Table-6 represent that the nutrient content of mushroom biscuits changed over control biscuits. The protein content increased 5.34%, 9.05% and 10.69% in 5, 10 and 15% mushroom powder biscuits respectively in comparison to control biscuits. There was a remarkable increase in ash and fiber percentage was found in 15% mushroom powder biscuits (18.33% and 13.42%) than to control biscuits.

Physical characteristics of biscuits

Physical characteristics of biscuits, such as bulk density, spread ratio and spread factor were affected by the replacement of mushroom powder. The analysis showed

Table 6: Nutrient content of mushroom biscuits changed over control biscuits

Samples	(% ±SD)				
	Moisture	Protein	Fat	Ash	Crude fiber
5% MF	18.02±1.40	5.34±1.40	3.86±0.41	3.43±0.52	5.37±0.90
10% MF	18.48±0.81	9.05±1.33	6.80±0.37	10.31±0.50	10.07±0.89
15% MF	17.75±0.94	10.69±1.41	8.27±0.70	18.33±0.57	13.42±0.67

Table 7: Physical characteristics of biscuits

Parameters	Level of mushroom flour (%)			
	Control	5% MF	10% MF	15% MF
Bulk density (g/cm^3±SD)	0.72±0.30	0.80±0.20	0.84±0.36	0.89±0.42
Spread ratio (g/cm±SD)	5.86±1.12	5.78±1.24	5.63±1.26	5.54±1.50
Spread factor	58.45±2.30	55.64±3.10	53.24±2.78	50.15±1.88

the bulk density of biscuits as 0.72, 0.80, 0.84 and 0.89 at the level of mushroom powder incorporation 0, 5, 10 and 15 respectively (Table-7). The changes in diameter and thickness reflected the spread ratio which was consistently decreased to from 5.78 to 5.54 as result of 15% levels substitution. These results indicate that the addition of mushroom powder adversely affected the thickness of biscuits. Its reason may be due to that the gluten network was weakened. Biscuits having higher spread ratios are considered most desirable (Kirssel and Prentice, 1979). Other research workers also reported that the thickness of supplemented biscuits were decreased, while, diameter and spread ratio of biscuits increased with increasing the level of rice starch blends (Abou- Zaid, 2011; Sudha et al., 2007). The analysis showed the spread factor of biscuits as 58.45, 55.64, 53.24 and 50.15 at the level of mushroom powder incorporation 0, 5, 10 and 15 respectively.

Table 8: Sensory evaluation of biscuits

Samples	Points Mean±SD					Total score
	Color and appearance	Texture	Taste	Aroma	Overall acceptability	
Control	7.83±0.78	8.07±1.00	8.05±1.00	7.89±0.93	8.12±0.93	39.96
5% MF	7.07±1.41	5.79±1.48	5.68±1.79	5.24±1.39	6.15±1.48	29.93
10% MF	6.73±1.48	6.69±1.41	5.78±1.50	6.89±1.27	6.25±1.45	32.35
15% MF	6.64±1.58	5.74±1.30	5.56±1.50	5.88±1.17	6.04±1.41	29.86

Comparison of organoleptic or sensory qualities of biscuits

Organoleptic tests of the biscuits depend on its first color, texture, taste, aroma and overall acceptability of the sample. Table-8 shows the comparison among the biscuits of their organoleptic quality factors. 15% mushroom powder biscuits obtained lower score (6.64) for its color and appearance. In the texture acceptability test, Hedonic scale showed that control biscuits liked very much by the Judge but 15% mushroom powder biscuits obtained second highest score. The taste and aroma mean score was also slightly higher in control biscuits than to mushroom biscuits. Control biscuits without incorporation of mushroom powder obtained the highest score for its overall acceptability after that 10% mushroom powder biscuits obtained second highest score than 5% and 15% mushroom powder biscuits. The total score for color, texture, taste, aroma and overall acceptability were 39.96, 29.93, 32.35 and 29.86 of control, 5%, 10% and 15% mushroom powder biscuits respectively.

Authors' Contributions

This original research work completed by M. F. A., supervised by U. K. P. and Co-supervised by K. M. M. R. L. This research work and manuscript preparation was completed in a suitable environment with an effective collaboration ofall authors.

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