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Research Article
Effect of Different Pretreatments on the Development of Oyster Mushroom Powder and its Utilization in Cookies Formulation

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Abstract

Background and Objectives: Mushroom recognised as a superfood due to its high nutritional status, on the contrary, it is highly perishable. Present study aims to prepare mushroom powder with various pre-treatments and its utilization in cookies. **Materials and Method:** Oyster mushroom (*Ploretus sajor-caju*) treated with pretreatments of potassium metabisulphite (KMS) and ethylene diamine tetraacetic acid (EDTA) to prevent browning. The sample exhibiting lowest browning were whey treated for different time 10, 20 and 30 min and dried to obtain mushroom powder. Developed powder was used for the enrichment of cookies. **Results:** Findings suggested 1% KMS treatment reduced browning intensity (BI) in comparison to other treatments (BI 0.013, 0.014 and 0.020). Whey treated mushroom (30 min) dried at 50°C for 1.5 h yielded 77.84% powder. Dried powder had 3.8% moisture and 20.3% protein. The mushroom powder incorporated in cookies at 2, 4, 6, 8 and 10%, enhanced protein and fibres content by 51 and 34% respectively. Physical properties i.e., diameter reduced from 88.2-85.00 mm, while thickness increased from 12.3-13.1 mm causing spread ratio to decrease from 7.17-6.48. Hardness measured were found to be directly influenced by mushroom powder incorporation. **Conclusion:** The cookies supplemented with mushroom would be a good source of protein and dietary fibre, which can be helpful in reducing malnutrition and constipation.

Key words: *Ploretus sajor-caju*, potassium metabisulphite (KMS), ethylene diamine tetraacetic acid (EDTA), whey, browning intensity, drying, mushroom powder, mushroom cookies

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Mushrooms regarded as functional food due to their high proteins with most amino acids, rich in dietary fibre, containing vitamins majority of B complex and vitamin D and minerals in abundance, low calorie with lacking cholesterol and attractive sensory characters making them a popular choice. Several health benefits of mushroom have been reported as boosting immune system, cholesterol-lowering properties, anti-hypertensive, anti-inflammatory, anti-diabetic, anti-viral and anti-microbial properties[1-5]. The mushroom production has seen a rapid spurt with more than 30 fold increase, with an increase in per-capita consumption, with China leading the world production status[6].

Mushrooms are highly perishable with very short shelf life-limiting their full economic utilisation. Several post-harvest processing causes sever quality deterioration such as enzymatic browning a major quality problem during processing and preservation[7]. Quality degradation such as moisture loss, discolouration, textural quality changes, nutrient and flavour loss, with an increase in microbial activity limiting their usage[8]. Considering its short shelf life for preserving such an important source of nutrients several thermal processing techniques in combination with chemical techniques are used for preserving its quality. Drying mushrooms and grinding to powder, using as a fortifying agent is mostly been reported in several food products, but sensitive to temperature changes, choosing appropriate pre-treatment and drying time-temperature determines the quality of final product[9].

Cookies form an important baked food widely consumed in western countries. Baked foods form the base for enrichment with various nutrients improving nutrition and quality. Considering the short life of mushroom and its browning behaviour on drying, this study evaluated the effect of different pre-treatments on drying behaviour of fresh mushrooms and development of mushroom powder with its utilisation for cookies formulation.

MATERIALS AND METHODS

Study area: This study was conducted at Department of food science and technology, Shivaji University, Kolhapur. The said trial was conducted in phases from June, 2016 to May, 2017.

Materials: The fresh oyster mushrooms (*Ploretus sajor-caju*) used in the study were procured from 'Balvant mushrooms', Kolhapur District of Maharashtra State, India. Food materials required for the formulation of cookies were food-grade and procured locally and chemicals of analytical grade were used for analysing the samples.

Pre-treatments: Freshly procured oyster mushrooms were washed with potable water and shredded to slices approximately 3 mm thickness using stainless steel cutter and subjected to dipping in 0.5% potassium meta bisulphate (KMS), 1% KMS and 0.75% ethylene diamine tetra acetic acid (EDTA) for 10 min to observe changes in browning.

Drying behaviour: Sample with lowest browning index were subjected to evaluate effects of drying time on particle size of mushroom powder. Based on best drying time and particle size, finally, samples were pre-treated with whey for 10, 20 and 30 min, respectively, improving the drying rate.

Cookies formulation: Refined wheat flour was replaced with five proportions 2, 4, 6, 8 and 10% and designated as C_1, C_2, C_3, C_4 and C_5, respectively, while C (without mushroom powder) was treated as control. The additional ingredients in the formulation are shown in Table 1.

Methods

Chemical composition: Samples were analysed for moisture by difference method, crude protein by Kjeldahl method, crude fat by soxhlet extraction, ash by charring the sample using muffle furnace and carbohydrate content by difference method as suggested by Ranganna[10]. Crude fibre content of mushrooms was analysed using Weendes method suggested by Sadasivam and Manickam[11]. While vitamin C content was evaluated using titrimetric method proposed by Egan *et al.*[12].

Browning Intensity: Browning intensity in fresh and dried mushrooms was measured by the method proposed by Ranveer *et al.*[13] with some modifications. Briefly, 5 g of sample was soaked in 50 mL of 1% H_2PO_4 for 30 min followed by blending and centrifuged at 8000 rpm for 20 min, centrifuged extract (20 mL) was mixed with an equal proportion of 95% ethanol. Mixture was filtered using Whatman No.4 filter paper and absorbance was recorded at 420 nm.

Table 1: Formulation of cookies supplemented with mushroom powder

	Sample code (weight (g))					
Ingredients	C	C_1	C_2	C_3	C_4	C_5
Refined wheat flour	50.0	50.0	50.0	50.0	50.0	50.0
Mushroom powder	0.0	2.4	4.8	7.2	9.6	12.0
Shortening	20.0	20.0	20.0	20.0	20.0	20.0
Sugar	37.5	37.5	37.5	37.5	37.5	37.5
Egg	12.5	12.5	12.5	12.5	12.5	12.5

C_1, C_2, C_3, C_4, C_5: Refined wheat flour with five proportions 2, 4, 6, 8 and 10%, respectively

Particle size: Particle size of ground powder developed by different pre-treatment was measured using sieve shaker procedure[14].

Physical properties of cookies: Physical properties such as diameter (D) was calculated using a ruler and observations were recorded in millimetre (mm), at a right angle and replicate were recorded by rotating the cookies by 60° angle as suggested by Rathore *et al.*[15]. Thickness (T) calculated by standard procedure[16] expressed as millimetre (mm). Spread ratio (SR) calculated as the ratio of D and T[15]. Cookies were evaluated for fracturability i.e., force required for shattering cookies using TA-XT2 texture analyser (Stable Micro Systems, UK) using 5kg load at speed of 1 mm sec^{-1}.

Sensory evaluation: Cookies developed by supplementing mushroom powder were analysed for sensory qualities using 9 point hedonic scale by semi-trained panellist[10].

Statistical analysis: Data were analysed to test significant difference by applying analysis of variance (ANOVA) tool available in MS-Excel 2013. The significant differences were tested at 5% level of significances[17].

RESULTS AND DISCUSSION

Effect of pre-treatments: Different pre-treatments were given to mushroom slices to prevent browning during drying, for powder preparation. Effect of different pre-treatments on browning of mushrooms at different time interval are shown in Table 2, along with visual observations. It was noticeable that KMS treatment at 1% concentration showed the lowest browning as compared to other treatments for different time intervals. The browning intensity is found to be influenced by the concentration of chemicals used in pre-treatments, leading to denaturation of enzyme protein causing reduction in browning[18]. Singh *et al.*[19] reported reduced enzymatic browning, retention of colour and textural properties and improved flavour by KMS treatment. Hence for further procedures for obtaining mushroom powder, 1% KMS pre-treatments was used due to lowest browning intensity as measured by noting absorbance and visual observations.

Effect of drying and whey treatment on drying behaviour: The mushrooms pre-treated with 1% KMS found suitable for reduced rate of browning was subjected to drying at different temperature range (Fig. 1) to reduce moisture upto 10% and observed periodically. Further upon samples arriving at 10% moisture level were cooled, ground to a fine powder and measured for particle size at less than 44 mesh as the major base material for formulation cookies being refined wheat

Table 2: Effect of different retreatments on browning intensity due to drying

Pre-treatments	Time interval (min)	Browning intensity (absorbance)	Visual observation
Fresh mushroom	0	0.012	Milky white
	15	0.029	Slight browning
	30	0.049	Brown
0.5% KMS	0	0.016	No browning
	15	0.019	No browning
	30	0.028	Slight browning
1% KMS	0	0.013	No browning
	15	0.014	No browning
	30	0.020	No browning
0.75% EDTA	0	0.035	Brown
	15	0.039	Brown
	30	0.044	Brown

KMS: Potassium metabisulphite, EDTA: Ethylene diamine tetraacetic acid

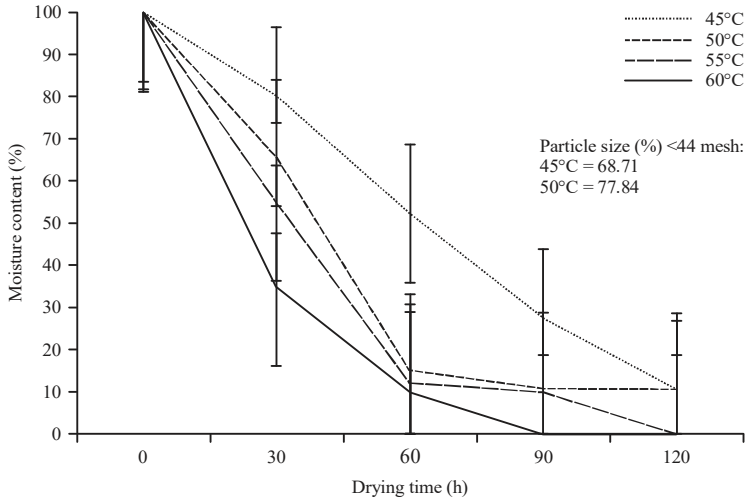

Fig. 1: Effect of drying temperature on drying of mushroom

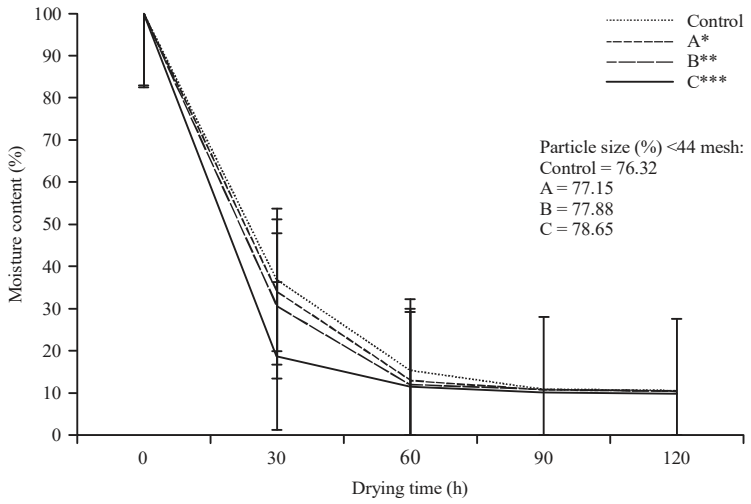

Fig. 2: Effect of whey treatment on mushroom drying at 50°C

*Whey treatment for 10 min, **Whey treatment for 20 min, ***Whey treatment for 30 min

Table 3: Chemical composition of fresh mushroom, mushroom powder and refined wheat flour

Components (%)	Fresh mushroom	Mushroom powder	Refined wheat flour
Moisture	90.03	3.80	14.81
Crude fat	1.80	1.84	0.16
Crude protein	2.86	20.30	11.12
Ash	0.61	7.02	0.79
Carbohydrate	4.30	57.84	72.60
Crude fibre	0.40	9.20	0.61
Vitamin C (mg %)	82.80	9.18	*

Table 4: Chemical composition of cookies formulated with different levels of mushroom powder

Components (%)	C	C_1	C_2	C_3	C_4	C_5
Moisture	2.31	2.48	3.01	3.13	3.52	3.72
Crude fat	39.61	39.62	39.71	39.74	39.82	39.83
Crude protein	5.20	6.28	7.81	8.62	9.42	10.15
Ash	0.30	0.42	0.76	0.90	0.93	0.98
Carbohydrate	52.19	49.76	47.99	46.59	45.31	44.22
Crude fibre	0.39	0.58	0.90	1.02	1.08	1.13
Energy (Kcal g^{-1})	586.05	580.74	580.59	578.50	577.30	575.95

C_1, C_2, C_3, C_4, C_5: Refined wheat flour with five proportions 2, 4, 6, 8 and 10%, respectively

flour had a particle size of 44 mesh was used, the powder was packed in airtight bags and stored. As per requirement sample dried at 50 for 120 min were found to yield maximum, as per our requirement hence drying at 50 for 120 min treatment was further used to obtain the powder. The general surface open cellular structure of oyster mushroom facilitates comparatively faster drying. Further treatment with whey, which is found to contain lactic acid bacteria, facilitating opening of pores inducing faster dehydration[20]. The results of different whey treatment are shown in Fig. 2. As expected the drying improved with increased whey treatment time and faster water evaporation rate during the first 30 min. It was noticed that pre-treatment with whey took less time as compared to control, drying time was found to be reduced by 25% to arrive at the desired moisture level. The highest yield at the desired particle size was achieved for sample C, i.e., whey dip treatment for 30 min.

Chemical composition: The nutritional composition of fresh mushroom and developed powder are presented in Table 3. The results for proteins were below the values reported for *Agaricus blazei* powder and higher for *Lentinus edodes* powder as reported by Carneiro *et al.*[21], where matching the previous finding for powder reported by Farzana and Mohajan[22]. While the nutritional composition of cookies formulated with mushroom powder are depicted in Table 4.

Moisture content: The moisture content of the cookies ranged 2.31-3.72%, which is lower than the maximum prescribed limit of 10% for biscuits preventing spoilage. The water content is seen to be rising with the increase in mushroom powder incorporation, which can be correlated to an increase in fibre and protein content improving water absorption and retention in cookies despite thermal treatment. Mushrooms are known to increase water holding and absorption capacity due to the abundance of polar amino acids, contributing to increased moisture[15,23]. Presence of wheat flour in the cookie formulation is also known to supplement cellulose enhancing the water absorption. Klunklin and Savage[24] reported an increase in moisture content of biscuits with increase in green-lipped mussel powder and spices.

Table 5: Physical properties of cookies supplemented with mushroom powder

Parameters	C	C_1	C_2	C_3	C_4	C_5
Diameter (mm)	88.20	88.00	86.90	87.30	88.60	85.00
Thickness (mm)	12.30	12.40	12.30	12.50	13.50	13.10
Spread ratio	7.17	7.09	7.06	6.94	6.71	6.48
Fracturability (N)	22.14	23.32	26.12	27.85	29.67	33.48

C_1, C_2, C_3, C_4, C_5: Refined wheat flour with five proportions 2, 4, 6, 8 and 10%, respectively

Protein and ash content: The results of the present study pointed out gradually increasing trend for protein (5.2-10.15%) and ash (0.30-0.98%) with increase in mushroom powder. Mushroom are well known for their richness in proteins and fibres, which has contributed to the rise in the content. These findings were supported by findings of Salehi[9] and Ng[25] for increase in protein and ash content with increase in addition of mushroom powder in biscuits and sponge cake.

Fat content: The fat content in the cookies increased non significantly from 39.61-39.83% with increase in incorporation of mushroom powder. The increase in fat content in the present study may be explained by the presence of shortening and refined wheat flour in the formulation. The trend for an increase in fat content were also reported in mushroom fortified biscuits and cookies[15,22,25].

Carbohydrate content: The highest carbohydrate content were reported in the control sample (52.19%) and decreased further. The decrease in carbohydrate could be the effect of reducing levels of refined wheat flours, substituted by mushroom powder. The similar trend for decrease in carbohydrate was supported by several findings[9,15,22].

Crude fibre content: Fibre is well known to avoid several diseases and mushroom is a well-known source of fibre[26]. Recent trend towards fibre enriched food products is on the rise especially wheat-based and baked foods[25]. The fibre content in the cookies formulated with mushroom powder is presented in Table 4. Basically, fibre content increased significantly due to increased level of mushroom powder added as reported by Parab *et al.*[27] in papad, in biscuits[22] and pasta[28] relevant to these findings.

Physical properties of cookies: The results of the effects of mushroom powder incorporation on cookies is presented in Table 5. It is found that the diameter of cookies reduced with increase in incorporation of mushroom powder, the highest value for diameter and thickness were found for 8% mushroom powder incorporation 88.6 and 13.5 mm, respectively. Spread ratio an important factor contributing to the shape of cookies, indicating their quality, spread ratio was inversely related with mushroom fortification. McWatters[29] reported a decrease in spread ratio for substitution with non-wheat flours. Generally, protein and fibres are well known to absorb and retain water increasing viscosity thus affecting the spread in cookies. Composite flour increases dough viscosity and aggregate formation due to limited free water availability in dough. Fuhr[30] reported flour or any other ingredients, absorbing water during dough formation, decreases spread ratio.

The hardness levels in cookies increased with an increase in the proportion of mushroom powder, hardness increased from 22.14-33.48 N from control to 10% mushroom powder incorporation. Fracturability in cookies is mainly influenced by protein starch interaction with water and fibre content[15,31]. High protein and fibre content in mushroom causes integration of starch gluten mixture increasing the force (N) required. Similarly, results with an increase in hardness of cookies with incorporation of fibrous ingredients were earlier reported for wheat and sesame peel composite flour cookies[32].

Sensory evaluation of cookies: The cookies formulated using different formulations were evaluated for sensory characters like colour, aroma, taste, mouthfeel, texture and overall acceptability. The results of sensory evaluation are shown in Fig. 3. The overall acceptability scores showed a decrease in overall acceptability with increase in mushroom powder incorporation. Taste and overall acceptability the major factor influencing the market acceptability of the sample. The score for taste and overall acceptability found to be decreasing similarly, with the highest score was obtained in control and lowest in C_5 in overall acceptability. The earlier findings of Kumar *et al.*[33] reported a negative relation between overall acceptability with increased levels of mushroom addition in sev matching our findings. The sensory evaluation also suggests partial replacement of refined wheat flour with mushroom powder to improve its nutritional value with acceptable sensory scores.

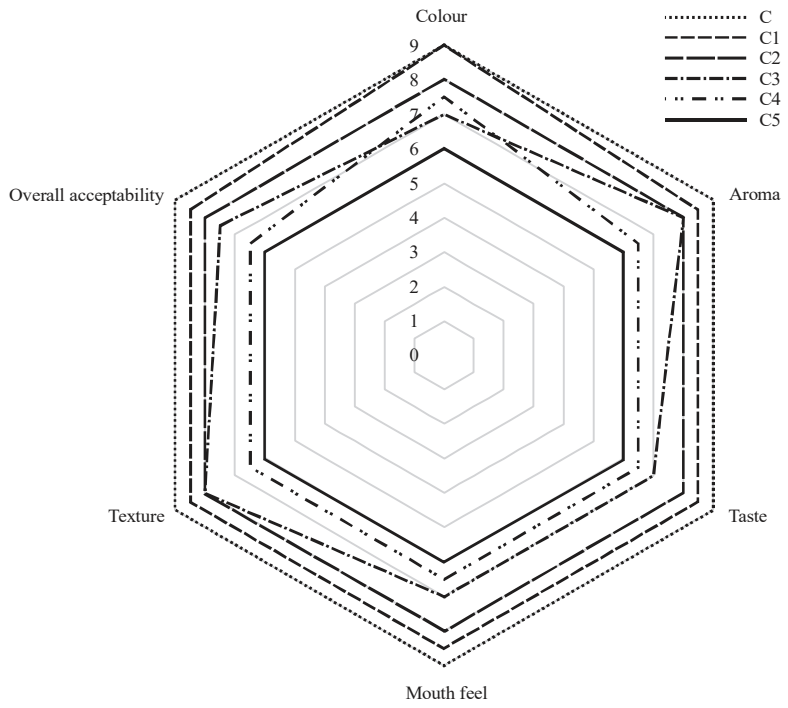

Fig. 3: Sensory qualities of cookies supplemented with mushroom powder

CONCLUSION

The results of the study illustrated that browning, major problem during drying of mushroom can be effectively reduced by pretreatment with 1% KMS and whey treatment for 30 min increased the drying yield at 50 with desirable particle size. The developed mushroom powder was supplemented in cookies formulation had acceptable sensorial characters. However, textural properties had some negative effect on fracturability of cookies.

Further study is proposed to identify the amino acid profile of the mushroom powder developed and their retention in the cookies under different baking methods with different detailed textural and nutritional quality changes.

SIGNIFICANCE STATEMENT

This study proposed information on pretreating mushroom, reducing the browning behaviour during drying and improved powder development, suitable for use in bakery products. Also, the developed powder was evaluated as supplementing agent for cookies. This study will provide insight for further reducing browning in mushroom during drying with improved rates and developing novel products enriched with mushroom.

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