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Enhancing nutritional quality of unleavened wheat flatbread using oyster mushroom flour

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ABSTRACT

Whole wheat meal was supplemented with oyster mushroom flour (OMF) to create a healthier version of unleavened flatbread. Oyster mushrooms were sundried and ground into flour to supplement at 5, 10, 15 and 20% in whole wheat meal. The addition of OMF significantly increased the water absorption (%) of dough, while dough handling was smooth and non-sticky. Prepared flatbreads showed full puffing in control, 5, 10 and 15% inclusion levels, while partial puffing was observed in flatbread containing 20% OMF. OMF significantly improved the flatbread's crude protein, crude fibre, and ash content. Moreover, compared to the control, a significant increase was observed in the in vitro protein digestibility (IVPD) of supplemented flatbreads. The sensory evaluation suggested that up to 15% OMF level in flatbread did not alter the sensory attributes and was acceptable and comparable with the wheat flatbread. Further, the trainees appreciated the dissemination of the technology using the household processing technique as it provides an economical means to add mushroom protein of high biological value to staple food.

Key words: Wheat flatbread, oyster mushroom, protein, house-hold processing

Mushroom cultivation is gaining popularity in India and edible mushrooms are a culinary delicacy owing to their texture and flavours. Apart from the delicacy, mushrooms are a powerhouse of nutrients such as protein, dietary fibre, minerals, and vitamins. Although mushrooms are eaten as a vegetable, it is a fungus whose protein is of high biological value with complete amino acids profile (González *et al.*, 2020). Mushrooms could be incorporated into the diets of the people from developing countries where high-quality animal protein is either unavailable or objectionable due to religious beliefs (Tolera and Abera, 2017). Cereals can be supplemented with mushrooms powder and thereby enhancing nutrition in one's diet. Mushrooms are acquiring significance in today's healthy diet due to their high digestibility and high nutritional value.

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Oyster mushrooms are easy to grow and could be easily used as a protein source in the diet. However, their perishability is an issue and if preserved, they could be easily used round the year in the diet. Dehydration is an easy and economical method to preserve mushrooms (Mutukwa *et al.*, 2019; Tran *et al.*, 2020). Sun-drying of oyster mushroom is a common method of preservation in rural areas. Dried oyster mushrooms could be used as a protein source in a variety of food products.

There are several studies focussed on the influence of mushroom flours on the physicochemical and sensory properties of culinary products (Biao *et al.*, 2020, Lu *et al.*, 2018, Ulziijargal *et al.*, 2013). These studies indicated that mushroom flour could be effectively incorporated into baked goods without

impairing their preparation or final properties, so long as excessive amounts were not added. Thus, adding mushroom flour to wheat flatbread could be an excellent way to improve the nutritional value of the staple cuisine. However, there needs to be more knowledge about the influence of sun-dried oyster mushrooms on flatbread's formation and quality attributes.

Thus, the present study evaluated the effects of partial substitution of wheat flour with OMF on the quality of the dough and flatbread. Specifically, the study sought to determine the physical, sensory, and nutritional effects of incorporating OMF at 5%, 10%, 15%, or 20% into wheat flatbread.

MATERIALS AND METHODS

Procurement and processing of oyster mushroom

Oyster mushrooms were procured from mushroom growers of Bathinda district. Fresh oyster mushrooms were cleaned and graded, damaged parts were removed and mushrooms were cut into appropriate sizes. Mushroom pieces were then treated with 2% brine solution for 5-6 minutes and steam blanched at 85ºC for 3-4 minutes. Blanched and treated mushroom pieces were placed in trays and divided into two segments. One segment was placed in hot air cabinet drier at 45°C for first 5-6 hours and then temperature was increased to 50ºC till completion of drying. Another segment was placed outside for sun drying. The dried mushroom were ground into fine powder using mixer cemotec mill and sifted through a sieve with 40 mesh size.

Incorporation of Mushroom powder in to wheat flour

The composite flour formulations were made by replacing whole wheat meal (WWM) with oyster mushroom flour (OMF) @ 5(F1), 10 (F2), 15 (F3) and 20% (F4). The supplementation level was selected on the basis of literature reviewed and initial trials. The composite flour samples were stored in airtight food grade plastic container at 5°C for further study. Oyster mushroom flour (OMF) and prepared flatbread were tested for their crude protein, crude fibre, and ash content using standard procedure (AACC, 2000). Results were reported on dry weight basis. Flatbreads were prepared as per Cheng and Bhat (2015) method with minor adjustments. The dough was prepared by adding water in WWM and composite flour. For each formulation, 500g sample was used to make dough in dough mixer (Kitchen aid). After mixing, wet muslin cloth was used to cover the dough and it was set aside for 30 minutes at 28±2°C. The dough balls were made and rolled into flatbreads using a roller. Prepared flatbread had a diameter of 12-14 cm and thickness of 2 mm. After rolling, flatbreads were baked on an iron tawa (pan) at 160-165°C for 1-2 minutes on both sides. Prepared flatbreads were cooled and packed for further analysis.

Physical quality attributes of flatbread

The puffed height was measured as full, partial and no puffing during baking (Dar *et al*., 2014). The colour of OMF in terms of 'L*', 'a*', 'b*' color scales (Nanke *et al*., 1999) was estimated using a Minolta CR-300 Chroma Meter (Konica Minolta, Osaka, Japan). The flatbread color was reported as hue angle (0.).

$$\text{Hue angle} = \tan^{-1} (b^*/a^*)$$

Textural properties of flatbreads were calculated as "shear rate' (Force in Newton) by texture Analyzer (Model LR-5K, Lloyd Instruments Limited, Hampshire, United Kingdom) using protocols of (Hemalatha *et al*., 2014). In vitro protein digestibility (IVPD) of flatbread was carried out using the multienzyme hydrolysis method (Hsu *et al*., 1977). Prepared flatbreads were assessed for sensory attributes using 9.0 point hedonic scale. 12 Semi-

trained panelists were selected for sensory analysis of flatbread samples.

Dissemination of technology

The purpose of the technology demonstration was to publicize the developed product and obtain feedback from end-users. For this purpose, 25 trainees, including small-scale cereal millers and producers were given a one-week training course on the "value addition of cereals and pulses." Under this programme, demonstrations were given for sun-drying of oyster mushrooms, pulverization of the sun-dried mushrooms and making of flatbreads. In addition, apprentices were given lectures on the nutritional value of wheat and mushrooms, as well as the significance of protein in the diet. More than fifty percent of the participants were local food processors and producers affiliated with active self-help groups increasingly engaged in the processing and value addition of cereals and pulses. The participant's responses to a questionnaire about the technology's utility and acceptability were recorded following the training.

Statistical analysis

The data were subjected to analysis of variance (ANOVA) to analyze the significance of the treatments used in this study using SPSS statistical software. The experiments were run in triplicates, and the results were stated as mean ± standard deviation (S.D). In this study, the confidence limit for ANOVA was 95% ($p<0.05$).

RESULTS AND DISCUSSION

Sun-dried OMF was compared with mechanically dried OMF, and results suggested a similar quality in terms of protein, ash and fibre (Table 1). However, a significant higher L* value of sun-dried sample was observed compared to mechanically dried samples, which indicates a lighter colour value of sun-dried sample. Earlier study reported that sun-dried apricot resulted in better retention of colour than hot air dried samples (Karabulut *et al.,* 2007).

Table 1. Proximate composition of sun-dried and cabinet-dried oyster mushrooms

Parameter	Sun-dried[#]	Mechanically-dried[#]
Moisture	8.32±0.59[a]	7.69±0.67[a]
Protein	30.23±1.15[a]	29.87±1.68[a]
Ash	10.59±0.58[a]	10.21±0.21[a]
crude fibre	9.89±0.81[a]	10.12±0.59[a]
L*	67.34±2.78[a]	64.49±3.78[b]
a*	2.78±0.12[a]	2.19±0.11[a]
b*	15.68±0.59[a]	14.56±0.47[b]

L: darkness to lightness; a: greenness to redness; b: blueness to yellowness; [#]mean ± standard deviation

Further sun-dried OMF was added to a whole wheat meal at different levels to prepare flatbreads. The addition of OMF significantly increased the dough's water absorption (%). The control sample had a 68.56 % water absorption rate, which increased to 73.48% and 73.89% for dough containing 15% and 20% OMF, respectively. 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 of the dough (Asghar *et al*., 2007). It is reported that water absorption increases with the increase in protein content. 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 fibre, sugars and higher protein content, which retain more water.

Flatbreads containing OMF had a higher shear rate than control. It might be due to the higher protein and fibre content of OMF resulting in a more compact structure of flatbread, which depicted a more rigid texture compared to wheat flatbread. Similar textural and crumb grain profiles have been stated previously

Table 2. Physical quality characteristics of dough and mushroom enriched flatbread

Sample	Water absorption (%)	Puffing	Shear rate (N)	Hue angle (0.)
Control	68.56±1.82^{b}	Full	8.56±0.87^{b}	80±1.00^{a}
F1 (5% OMF)	69.25±2.45.^{ab}	Full	8.49±0.64^{b}	81±0.00^{a}
F2 (10% OMF)	72.28±1.89^{a}	Full	9.34±0.69^{a}	82±0.00^{a}
F3 (15% OMF)	73.48±1.38^{a}	Full	9.50±0.78^{a}	81±1.00^{a}
F4 (20% OMF)	73.89±2.67^{a}	Partial	9.89±0.72^{a}	82±0.00^{a}

by means of sensorial and instrumental studies of bread (Shittu *et al*., 2007). Colour is a crucial factor in the acceptance of food products. Results suggested that OMF enriched flatbread had a higher hue angle than control, indicating a lighter colour than control, however, the increase was non-significant. Therefore, we can conclude that the addition of OMF did not affect the colour of the flatbread. The darkened color of crust may be due to the Maillard reaction taking place during baking of loaves, due to high lysine contents. Hussain (2004) reported 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 more than 15 % mushroom powder.

Further, flatbreads were analyzed for proximate composition and IVPD (Table 3). The addition of OMF significantly increased the crude protein, crude fibre and ash content compared to the control. Flatbread containing 15% OMF had 36% higher protein and 122% higher fibre content than whole wheat meal flatbread. A previous study (Ishara *et al*., 2018) reported that the addition of mushroom flour (MF) in maize flour significantly increased the protein content from 6.90% in control to 19.32% in maize flour supplemented with 50% MF. Further, the addition of OMF significantly improved the *in vitro* protein digestibility (IVPD). The control sample had an IVPD of 62%, which increased to 74% and 76% for flatbreads containing 15% and 20% OMF. Higher IVPD indicates a better quality of protein, and the addition of mushroom powder improved the amino acid profile of the WWM. The addition of OMF not only increased the protein quantity but also improved the quality of the protein depicted from higher IVPD of OMP-enriched flatbread compared to the control.

Sensory analysis suggested that the acceptability of OMF-enriched flatbreads was comparable with the control. The aroma of the OMF-enriched flatbread scored more compared to the control. However, the colour and texture scores of control and enriched were almost similar. Pliability scores of OMF enriched flatbread at 15 and 20% were significantly lower than the control. This might be due to the compact texture of flatbread due to OMF addition compared to the control sample. However, overall acceptability scores

Table 3. Chemical composition and IVPD of flatbreads

Sample	Crude Protein (%)	Crude Fibre (%)	Ash (%)	IVPD (%)
Control	8.09±0.78^{d}	1.38±0.05^{c}	1.05±0.21^{bc}	62±2.78^{d}
F1 (5% OMF)	8.78±0.93^{d}	2.12±0.12^{b}	1.24±0.15^{b}	65±1.78^{c}
F2 (10% OMF)	9.67±0.76^{c}	2.55±0.18^{ab}	1.59±0.12^{ab}	71±2.38^{b}
F3 (15% OMF)	11.03±1.02^{b}	3.07±0.15^{a}	2.13±0.19^{a}	74±1.67^{a}
F4 (20% OMF)	12.14±1.16^{a}	3.54±0.32^{a}	2.58±0.12^{a}	76±1.59^{a}

of OMF were in the higher range and well comparable with the control. Therefore, based on sensory scores, flatbread supplemented with 15% OMF was selected as the best level (Fig 1).

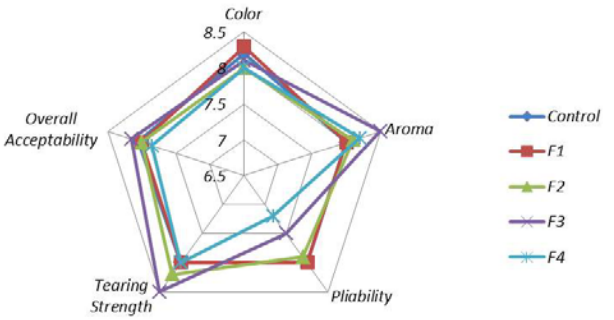

Fig. 1. Radar graph of sensory quality of flatbreads

Technology dissemination

In a skill development training programme, sundried OMF was supplemented with a whole wheat meal at 15% to prepare flatbreads. The participants were asked questions to evaluate the acceptability and creditability of the technique for end users. Results suggested that mushroom cultivation is gaining interest as 48% of respondent were aware that mushrooms are known to be an excellent source of protein with complete amino acids, and one-third of the participant (27.50%) were aware of mushroom use as a protein source. As sun drying is one of the economical preservation methods, 78.50% of the respondents were aware of sun drying oyster mushrooms for an extended time; however, only 17.70% of respondents knew that mushrooms could be supplemented as a protein source in food products. Nevertheless, most of the respondents (>80%) agreed that sun-drying of oyster mushrooms and their supplementation in whole wheat meals for making flatbread with improved nutrition are easy and cost-effective techniques. Moreover, 97.28% of the respondents agreed that the sensory quality of OMF-supplemented flatbread was excellent and comparable to the control. The

Table 4. Response of participants towards the sundried OMF enriched flatbread technique

	Attributes regarding mushroom enriched wheat flatbread	Responses		
a	Knowledge of mushroom cultivation	Not aware (52%)	Aware (48%)	-
b	Knowledge of mushroom being an excellent protein source	Not Aware (72.5%)	Aware (27.5%)	-
c	Sun drying of oyster mushroom	Not Aware (21.50%)	Aware (78.50%)	-
d	Mushroom powder supplementation as a protein source	Not aware (82.30%)	Aware (17.70%)	-
e	Easy to adopt technique	Strongly agree (82.80%)	Neither agree nor disagree	Disagree (7.50%) (9.70%)
f	Cost effective	Strongly agree (85.50%)	Neither agree nor disagree	Disagree (3.14%) (11.36%)
g	Organoleptic qualities* of enriched flatbread are comparable to control	Strongly agree (97.28%)	Neither agree nor disagree (2.72%)	-
h	Overall the household technique is efficient for preparing mushroom enriched wheat flatbread	Strongly agree (94.40%)	Neither agree nor Disagree (4.26%)	Disagree (1.34%)

*Organoleptic qualities include colour, taste and aroma

technology dissemination concluded that participants had a positive approach regarding the technique and that it could be used both at household and industrial scales for improving the nutritional quality of existing and novel food products.

CONCLUSION

The addition of sun-dried oyster mushroom flour @ 15% in whole wheat meal resulted in flatbread with improved nutrition. The enriched flatbread had 36% higher protein and 122% higher fibre content than the control wheat flatbread. Moreover, the addition of OMF balanced the amino acid profile of enriched flatbread and increased IVPD than the control sample. Physical characteristics suggested that the addition of OMF did not alter the puffing and colour characteristics of the flatbreads. Further, the technology was liked and accepted when demonstrated in a training programme. Most of the respondents agreed that the technology is easy and economical to add quality proteins to the diet and sensory attributes of the enriched flatbread were comparable to the control.

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CONFLICT OF INTEREST

The authors declare no conflict of interest with other researchers.

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