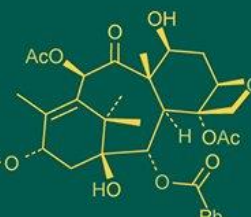
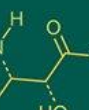
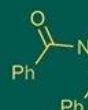


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Development of mushroom-enriched soup mix and nachos using oyster mushroom powder

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Abstract

Background: The oyster mushrooms (*Pleurotus ostreatus*) are highly nutritious functional foods, and their nutritional quality depends on the drying process and level of incorporation.

Objective: This research examined various drying methods of the oyster mushroom powder and its incorporation in the development of nutritious and sensory-acceptable soup mix and multigrain baked nachos.

Methods: Various drying methods were used to prepare the oyster mushroom powder which was then incorporated (10-20%) in soup mix and multigrain baked nachos, and their nutritional and sensory qualities were evaluated.

Results: The oven-dried mushroom powder had the best nutritional quality as it had high levels of protein and fiber, and low levels of moisture. The products incorporating 15% oyster mushroom powder had the best sensory acceptability. Higher incorporation of oyster mushroom powder significantly improved the levels of protein, fiber, ash, iron, and zinc but decreased carbohydrate levels with little changes in the energy level.

Conclusion: The research concluded that the oven-dried oyster mushroom powder incorporated at 15% is ideal for nutritious and sensory-acceptable soups and baked foods.

Keywords: Functional food, multigrain baked nachos, mushroom, nutritional enrichment

Introduction

Over the years, increased consumer awareness about health, nutrition, and sustainability has increased the demand for functional foods that offer health benefits aside from being nutritive. Concerns about climate change, food security, and environmental destruction have added urgency to the development of sustainable and nutritious food sources. It is under this circumstance that mushrooms have come to be seen as climate-resilient food crops that are beneficial not only in providing nutrition but also in ensuring environmental sustainability. The mushrooms especially the oyster mushroom (*Pleurotus ostreatus*) have received much attention owing to their nutritional composition, which consists of high-quality proteins, fiber, minerals, and various bioactive compounds (Aditya *et al.*, 2024) ^[1]. The oyster mushroom is low on fat and caloric content and is a good source of iron, zinc, potassium, B vitamins, and antioxidants (Timaná *et al.*, 2024) ^[2]. Apart from the nutritive value, the oyster mushroom contains bioactive compounds like beta-glucans, phenolics, and polysaccharides with antioxidant, immunomodulatory, and cholesterol-lowering effects.

In terms of climate change and sustainability, one of the most significant benefits associated with oyster mushrooms is that they can be grown using a variety of agricultural wastes like wheat straw, paddy straw, and lignocellulose wastes. Besides helping to recycle waste and promoting circular food systems, this also helps save space, energy, and water compared to the production of meat proteins. Moreover, growing mushrooms has a lower greenhouse gas emission potential which makes them a good choice for climate-smart nutrition which seeks to mitigate the effects of food systems on the environment while improving nutrition outcomes. However, fresh mushrooms are very perishable due to their high moisture content (Oladeji *et al.*, 2025; Tolera & Abera 2017) ^[3, 4]. Drying has been among the most popular means of preservation which extends shelf-life and ensures storage stability. The method used in the drying process influences greatly the nutritional value, sensory characteristics, and functionality of the resulting mushroom powder. Conventional sun drying, blanching prior to sun drying, and oven drying have been among the common methods, all affecting the

products differently in terms of nutrient content, color, texture, and bioactive compounds. Inclusion of the mushroom powder in common foods such as soups and snacks represents an ideal method of increasing nutrient intake without having to change much the eating patterns. Instant soup mix and multi-grain baked snacks represent common products which have been increasing in popularity because of their high acceptability (Pamalka *et al.*, 2026) [5]. Such products make ideal vehicles for delivery of functional ingredients like mushroom powder to improve protein quality, fiber content and micronutrient levels especially iron and zinc.

Consequently, the current research was carried out in order to examine the impact of various drying techniques on the nutritional quality of oyster mushroom flour and the formulation of mushroom fortified soup powder and multigrain baked nachos. The objectives of this research work were to examine the sensory acceptance and nutritional improvement by incorporating the various amounts of mushroom powder into the products.

Materials and Methods

Raw Materials

Fresh oyster mushrooms (*Pleurotus ostreatus*) were chosen for the development of enriched mushroom soup mix and multigrain baked nachos. The mushrooms were sourced from the Department of Plant Pathology/Soil Science of C.S. Azad University of Agriculture and Technology

(CSAUA&T), Kanpur. The mushrooms that were chosen for processing were fresh and healthy.

Other ingredients that were needed for product development like corn flour, milk powder, barley flour, whole wheat flour, ragi flour, rice flour, salt, black pepper, mixed herbs, oregano, butter, and baking powder were obtained from the local market of Kanpur city.

Processing of Oyster Mushrooms

The following steps were conducted prior to drying the mushrooms:

- **Selection:** Discarding of damaged or malformed mushrooms
- **Washing:** Thorough washing in clean drinking water to clean off any dirt or impurities
- **Straining:** Removal of excess water using a colander and wiping with a clean muslin cloth

Preparation of Oyster Mushroom Powder (OMP)

Oyster mushroom powder was prepared using three different drying methods:

1. Sun Drying (SD)

One kg of prepared mushrooms was evenly spread in stainless steel trays and dried under the sun for 4-5 days. The drying process was repeated until mushrooms were dry and hard. About 100-120 g of dried mushrooms was collected in sealed containers.



Fig 1: Oyster Mushroom after Sun Drying

2. Blanching and Sun Drying (BSD)

The cleaned mushrooms were subjected to blanching by boiling them in water (100 °C) for 2 minutes and then

immediately cooling them in cold water, drained and dried in the sun using the same method as sun drying until a crisp consistency was attained.



Fig 2: Oyster Mushroom after Blanching and sun drying

3. Oven Drying (OD)

Washed mushrooms (1 kg) were spread out evenly in trays and subjected to oven drying using hot air at 60 °C for 6 to 8 hours until thoroughly dried. Once cooled to room temperature, dried mushrooms (100 to 120 g) were kept in air-tight containers.



Fig 3: Oyster Mushroom after Oven Drying

All the dried samples were reduced to powdered form using a laboratory grinder and kept in air-tight glass bottles at cool and dry conditions for further use.

Development of Mushroom-Enhanced Foods

Soup Mix

The soup mix was made using the oyster mushroom powder, corn flour, milk powder, black pepper powder, oregano, and salt. The mushroom powder that was made using three drying processes was mixed in an equal proportion (1:1:1). The recipes for soup mixes were prepared by adding four different levels of mushroom powder:

Table 1: Recipe for Soup Mix Prepared from Oyster Mushroom Powder

Ingredients	T ₀	T ₁	T ₂	T ₃
Oyster Mushroom Powder	0 g	10 g	15 g	20 g
Corn Flour	50 g	45 g	42 g	40 g
Milk Powder	40 g	38g	36 g	34g
Black Pepper Powder	3 g	3 g	3 g	3 g
Oregano (Dried)	2 g	2 g	2 g	2 g
Salt	5 g	5 g	5 g	5 g

Multigrain Baked Nachos

The preparation of mushroom-added baked nachos was done with the use of barley flour, whole wheat flour, ragi flour, rice flour, oyster mushroom powder, herbal mixture, butter, baking powder, and salt. The oyster mushroom powder was added to different levels, namely 10%, 15%, and 25%.

Table 2: Recipe for Baked Nachos Prepared from Oyster Mushroom Powder

Ingredients	T ₀	T ₁	T ₂	T ₃
Barley Flour	40 g	35 g	30 g	25 g
Whole Wheat Flour	40 g	23 g	20 g	15 g
Ragi Flour	10 g	12 g	15 g	12 g
Oyster Mushroom Powder	0 g	10 g	15 g	25 g
Chilli Powder	1 g	1 g	1 g	1 g
Butter	2 g	3 g	3 g	3 g
Baking Powder	0.5 g	0.5 g	0.5 g	0.5 g
Salt	2 g	2 g	2 g	2 g



Fig 3: Controlled and Oyster-mushroom formulated Multi-grain Baked Nachos

Sensory Evaluation

The sensory analysis of the formulated soup mixture and baked nachos was done through the use of a 9-point hedonic scale to evaluate appearance, color, taste, flavor, texture, and general acceptability. A semi-trained panel was used, and mean scores determined. The results were subjected to statistical tests at the 5% significance level.

Nutritional Analysis

Nutritional composition analysis of powdered oyster mushrooms and developed products were conducted following standard methods for moisture, crude protein, crude fat, crude fiber, total ash, and carbohydrate (difference method) as per AOAC standards of 1980 and 1995. Energy content calculations were done using Atwater coefficients. Mineral contents (iron and zinc) were determined using colorimetry method through dry ashing following procedure outlined by Ranganna (1986).

Results and Discussion

Chemical Composition of Oyster Mushroom Powder

The most effective nutritional preservation was exhibited by oven drying due to the minimum moisture level (7.40%), maximum protein (29.80%), and maximum crude fiber (7.80%) content. The controlled temperature and fast drying reduced enzyme breakdown and loss of nutrients. Moderate levels of nutrients were maintained in the case of sun drying, while the blanching then sun drying led to increased moisture and decreased protein level. This is in agreement with past literature (Muyanja *et al.*, 2014; Majeed *et al.*, 2017) [6, 7].

Table 3: Sun drying, Blanching + Sun Drying and Oven Drying Method Oyster Mushroom Powder

Parameters	Sun drying Mean & SD	Blanching + Sun Drying Mean & SD	Oven Drying Mean & SD
Moisture	8.20±0.11	9.10±0.12	7.40±0.14
Protein	28.40±0.27	26.50±0.25	29.80±0.30
Fat	2.30±0.08	2.00±0.07	2.10±0.06
Carbohydrates	53.10±0.35	51.20±0.40	52.00±0.35
Crude Fibre	7.50±0.14	6.90±0.15	7.80±0.15
Total Ash	5.70±0.09	5.50±0.10	6.00±0.10

Sensory Evaluation of Mushroom-Enriched Soup Mix

Sensory scores increased with an increase in inclusion of mushroom powder to 15% (T₂). The treatment T₂ scored the highest mean scores for appearance, color, taste, flavor, texture, and overall acceptance. While the difference

between treatments was not statistically significant, the panellists always preferred T₂.

The superior sensory performance can be associated with the umami flavor components found in oyster mushrooms

that enhanced the taste and flavor of the product without affecting its color and texture negatively. This has been observed by Masiko *et al.*, (2023) ^[8] and Dhanapal *et al.*, (2023) ^[9].

Table 6: Sensory Evaluation of Control and Incorporated Soup Mix

Parameter	Control (T ₀)	T ₁ (10% Oyster Mushroom Powder)	T ₂ (15% Oyster Mushroom Powder)	T ₃ (20% Oyster Mushroom Powder)	CD (5%)	S.E. (±)
Appearance	7.2	7.6	8.0	7.8	0.3124	0.1121
Colour	7.4	7.8	8.2	8.0	0.2689	0.0954
Taste	7.8	8.2	8.4	8.2	0.3623	0.1217
Flavour	7.6	8.0	8.3	8.1	0.2921	0.0933
Texture	7.9	8.1	8.4	8.3	0.4182	0.1751
Overall Acceptability	7.7	8.1	8.3	8.1	0.2865	0.0827

Sensory Evaluation of Mushroom-Enriched Baked Nachos

Nacho chips with mushrooms also performed better in terms of sensory attributes with an increase in percentage of mushrooms. T₂ treatment having 15% of mushroom powder resulted in maximum scores for appearance, taste, texture,

and overall acceptance. The crispy texture and flavor profile could be attributed to the synergy between fiber and protein from mushrooms with cereal flour. This is in line with the study of Rathore *et al.*, (2017) ^[10] and Sharma *et al.*, (2017) ^[11].

Table 7: Sensory Evaluation of Control and Incorporated Multigrain Baked Nachos

Parameter	Control (T ₀)	T ₁ (10% Oyster Mushroom Powder)	T ₂ (15% Oyster Mushroom Powder)	T ₃ (20% Oyster Mushroom Powder)	CD (5%)	S.E. (±)
Appearance	7.4	7.8	8.2	7.9	0.3412	0.1152
Colour	7.6	8.0	8.3	7.8	0.2893	0.0984
Taste	7.4	8.3	8.5	8.0	0.3756	0.1243
Flavour	7.5	8.1	8.4	8.0	0.3044	0.0967
Texture	7.8	8.4	8.6	8.2	0.4912	0.1705
Overall Acceptability	7.6	8.3	8.5	8.0	0.2768	0.0845

Nutritional Composition of Mushroom-Enriched Soup Mix

With an increase in mushroom powder, the percentage of protein, ash, crude fiber, iron, and zinc content increased significantly, while the percentage of carbohydrate content reduced. The maximum percentage of protein (15.9%), fiber

(6.4%), iron (3.0 mg/100 g), and zinc (2.0 mg/100 g) was recorded in T₃. There was no significant change in the energy content with different levels of treatments. This shows the efficiency of the use of oyster mushroom powder as a rich source of protein and minerals, just like those found by Siyame (2021) ^[12] and Jinzhuang *et al.*, (2025) ^[13].

Table 8: Nutritional Composition of Control and Formulated Mushroom enriched Soup Mix (in 100 g)

Parameter	Control (T ₀)	T ₁ (10% Oyster Mushroom Powder)	T ₂ (15% Oyster Mushroom Powder)	T ₃ (20% Oyster Mushroom Powder)	CD (5%)	S.E. (±)
Moisture (%)	6.5	6.1	5.8	5.5	0.318	0.105
Crude Protein (%)	9.4	13.5	14.8	15.9	0.425	0.141
Crude Fat (%)	12.3	12.0	11.9	11.7	0.362	0.120
Crude Fiber (%)	2.2	4.1	5.3	6.4	0.385	0.132
Total Ash (%)	6.8	8.0	9.2	10.3	0.410	0.138
Carbohydrates (%)	62.8	56.3	53.0	50.2	0.470	0.154
Energy (Kal/100 g)	413.6	414.7	413.8	412.3	1.72	0.58
Iron (mg/100 g)	1.4	2.1	2.6	3.0	0.245	0.082
Zinc (mg/100 g)	0.9	1.4	1.7	2.0	0.210	0.071

Nutritional Composition of Mushroom-Enriched Multigrain Baked Nachos

Incorporation of mushrooms substantially increased the content of protein, fiber, ash, iron, and zinc while decreasing the carbohydrate content. The maximum nutrient density was seen in T₃, but T₂ incorporated the best ratio of nutrition

and acceptability.

The findings have shown that mushroom powder is capable of making conventional snacks into functional foods, which is consistent with previous findings of Srivastava *et al.*, (2024) ^[14] and Schneider *et al.*, (2025) ^[15].

Table 9: Nutritional Composition of Control and Formulated Mushroom enriched Multigrain Baked Nachos (in 100 g)

Parameter	Control (T ₀)	T ₁ (10% Oyster Mushroom Powder)	T ₂ (15% Oyster Mushroom Powder)	T ₃ (20% Oyster Mushroom Powder)	CD (5%)	S.E. (±)
Moisture (%)	10.2	9.5	8.9	8.5	0.368	0.112
Crude Protein (%)	9.6	10.7	11.4	12.3	0.417	0.138
Crude Fat (%)	8.6	9.4	9.7	10.1	0.351	0.116
Crude Fiber (%)	4.4	5.3	6.2	7.1	0.378	0.126
Total Ash (%)	2.5	3.6	4.3	5.2	0.392	0.130
Carbohydrates (%)	64.7	61.5	59.5	56.8	0.434	0.147
Energy (Kal/100 g)	396.2	401.7	404.1	406.5	1.84	0.61
Iron (mg/100 g)	2.5	3.1	3.7	4.3	0.228	0.078
Zinc (mg/100 g)	1.9	2.3	2.7	3.1	0.196	0.066

Conclusion

The above study is clear evidence of the capability of oyster mushroom powder as a nutritious component to develop nutrition-rich food items. In comparison to the other two drying processes, oven drying was found to be most efficient in retaining the nutritional quality as it generated mushroom powder that had the least moisture and the most amount of protein and crude fiber. The addition of mushroom powder in soup mix and multigrain baked nachos significantly increased their nutrition values through increased levels of protein, fiber, ash, iron, and zinc contents but decreased carbohydrate content. Sensory tests revealed that soup mixes and nachos with 15% of mushroom powder were the most acceptable to consumers.

On the whole, this study showed the possibility of using oyster mushroom powder for developing functional foods out of regular soup mixes and snacks. These value-added foods could be considered suitable for commercialization.

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