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Effect of thermal preservation on important nutritional parameters of edible mushrooms

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Mushrooms, known for their high nutritional value and economic significance, are prone to rapid spoilage due to their high moisture content and susceptibility to microbial growth. This study investigates thermal preservation techniques, specifically sun-drying and microwave drying, to extend the shelf life of two major edible mushroom species-*Pleurotus ostreatus* (Oyster mushroom) and *Agaricus bisporus* (Button mushroom). These methods reduce moisture content, inhibit microbial growth, and preserve key nutrients such as protein, carbohydrates, and minerals (N, K, Na, Fe, Zn, Ca, Mg). Microwave drying offers a faster preservation process while maintaining texture, while sun-drying, conducted at controlled temperatures (38°-40°C) and relative humidity (78-80%), also effectively extends shelf life. Both methods showed minimal nutrient degradation, making them valuable for enhancing mushroom utility in both domestic and commercial settings. These preservation techniques could play a key role in improving food security and nutritional access, especially in regions where mushroom production is vital.

Keywords : Microwave drying, mushroom. preservation, shelf life, sun-drying

INTRODUCTION

Mushrooms have been utilized as food and neutraceuticals since the beginning of time, as evidenced by the descriptions of them in ancient epics such as the Bible and Vedas. They are macro-fungi that have recognizable fruiting bodies that are large enough to be harvested by hand and seen with the unaided eye. Considering what mushrooms stand for in four categories apply to the food and health of humans that is edible, medicinal, toxic, and other mushrooms, the characteristics of which are still unknown (Cheung, 2010).

Certain edible mushrooms can be categorised as both medicinal and edible at the same time since they have both edible and medicinal qualities (Guillamo'n *et al.,* 2010).Oyster and white button mushrooms are the most widely accessible types in Nepalese markets due to their adaptability to a wide range of climates (Parajuli, 2014; Yang *et al*., 2013). Because they include fibre and soluble protein, two things that are absolutely necessary, FAOSTAT reports that the total amount of mushrooms produced worldwide in 2019 was 1,18,98,399 tonnes (FAO, 2019). 98% of the mushrooms produced worldwide were produced in China, Japan, India, Iran, the United States of America, Canada, the European Union, the Russian Federation, and Australia. Asia accounted for a large portion of manufacturing. Asian mushroom output reached 9,854,391 tonne in 2019, according to FAOSTAT. China, Japan, and India accounted for more than 97% of the manufacturing in Asia (FAO, 2019).In addition to being a good source of protein, dietary fibre, minerals, and vitamins, mushrooms also have a lowcalorie content (Kulshreshtha *et al*., 2009). Instead of being stored as starch, 63% of the carbohydrates in mushrooms are stored as glycogen, chitin, and hemicellulose. Additionally, mushrooms are regarded as a storehouse of fat (5%) and protein (22%) that contains linoleic acid and important essential amino acids. Numerous substances, such as flavonoids, phenolics, vitamins (thiamine, C, riboflavin, niacin, and

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tocopherols), and beneficial minerals (K and P) can be found in mushrooms (Chaturvedi *et al.,* 2018; Ramteke *et al*. 2020).According to Abatenh and Gizaw (2018), the preservation of mushrooms is required because it regularly loses its velvety texture. Future applications of this technology are required in a number of domains, including industrial systems, pathological, taxonomical, ecological, and biotechnological systems, as well as studies and applications pertaining to biodiversity (Zhang, *et al*., 2018). Currently, there is a growing interest in the acquisition and study of the physiologically active compounds obtained from higher Basidiomycetes. There is a decrease in the quantity of carbohydrates and protein. It begins to take on a brown colour. Reduce the amount of soluble chemicals. For further cultural conservation, characterization, and identification; to tackle the effects of both natural and man-made factors on species diversity, or abundance. Since it spoils easily, it is utilized to maintain food security and safety. Both morphological alteration and the likelihood of contamination are lessened. The world's population is still growing, which has led to a surge in poverty. Smaller farms are also generating less land because of lower soil fertility. It is used to introduce bio-innovations to expand the scope of sustainable forestry and agriculture.In addition to their nutritional worth and many varieties, edible mushrooms require certain preservation techniques to maintain their high quality and nutritional characteristics over an extended period of time. Keeping in view the above aspects, a study was conducted to evaluate the effectiveness of various mushroom thermal preservation methods, assess the nutritional content of preserved mushrooms.

MATERIALS AND METHODS

Sundry Method

Sun drying was done in accordance with Dunkwal *et al*. (2007). One kilogram of oyster mushroom slices were arranged on trays, being careful not to touch, and then exposed to seven days of sun drying at a temperature of between 25°Cand 37°C and a relative humidity of between 41% and 46%.The mushrooms were checked and flipped often to encourage efficient drying during the drying process. To encourage airflow, the drying process was done outside. Until they were needed for additional examination, the dried mushrooms were kept in a cold place in sealed plastic bags.Each replication technique uses two hundred grams of button mushroom (*Agaricus bisporus*) and oyster mushrooms (*Pleurotus ostreatus*); three replications of these procedures have been carried out. The healthy mushrooms are separated and thoroughly cleaned after the sample is taken. The mushroom samples are cleaned and then thinly sliced. Extra water has been soaked with towel. After that, the chopped mushrooms are transferred to fresh platters and left to bake in the intense sun. The samples are adequately dried after 6-9 days. But excessive humidity is a challenge for these processes.

Microwave Method

According to Dawadi *et al*.,(2022); drying the mushrooms is a long-term storage method that improves their flavour and maintains their freshness. Drying of mushrooms can be done quickly mushrooms with either heat or air. *Agaricus bisporus* (button mushrooms) and *Pleurotus ostreatus* (oyster mushrooms), weighing 200g each, are used in each replication procedure. There have been three replications of these individual procedures completed. Following the collection of the sample, the healthy mushrooms are divided and given a thorough cleaning. After the mushroom samples are thoroughly cleaned, they are thinly and evenly sliced. The mushrooms are then divided into slices and placed on baking sheets so that they are not in contact with one another. After that, put it in the microwave and turn it on. The sliced samples are flipped halfway through the frying process and fried once more. The samples therefore cannot be burned. Fry them until they take on a crunchy, crispy texture. The slices are carefully cooled and stored in zip-lock bags after the procedure is finished.

Total nitrogen of dried mushroom Digestion Process

Two different kinds of mushrooms, button mushroom and oyster mushroom with different preservation methods weighing 0.5 g each were

taken to the digestion tube from each treated substrate in this operation. The substance was combined with 5 g of digestion activator and 10 ml of concentrated sulfuric acid (H_2SO_4). The digestion blocks were heated after the tubes were loaded into the digester. The digestion unit was initially set to 100°C until frothing was gone, and then the block temperature was raised to 400°C because effective digestion only starts at 360°C and above 410°C. After the digestion process was complete, the samples' colour disappeared.

Distillation Process

As soon as the acid in the digested tube sample was neutralized through heating, the sample's ammonium radicals were transformed into ammonia through distillation using 40 ml of 40% NaOH in an excess alkali reaction. Following the addition of 40% NaOH, which is dissolved in 20 ml of a mixed indicator solution containing 4% boric acid and kept in a 250 ml conical flask, the digested samples were heated largely by the passage of steam. This allowed the ammonia to be released. After absorbing ammonia, the pinkish colour turns green. 45% cc of distillate are collected in around eight minutes. Also must be run concurrently is a blank sample (one that has neither dirt nor plants in it). The sample of boric acid is then obtained for titration after ammonia has been dissolved in it.

Titration Process

Using 40 ml of 40% NaOH during distillation converts the sample's ammonium radicals to ammonia, an extreme alkali state. The green colour distillate solution of boric acid and mixed indicator including "distilled off" ammonia was titrated with standardized 0.02N $H_2 SO_4$ until the colour returned to its natural shade, which is pinkish. The titration value of a blank boric acid and mixed indicator solution was determined. The percentage of nitrogen in the culture filtrate was determined using the following formula :

$$\text{Nitrogen content (\%)} = \frac{\text{(Sample titer – Blank titer) x Normality of H2SO4 x 14 x100}}{\text{Sample weight x 1000}}$$

Crude Protein content

Following the guidelines provided by AOAC (1995), the crude protein is computed using the following formula, and the total nitrogen is estimated using the micro-Kjeldahl method. A micro-Kjeldahl flask was filled with a 0.5 g dried mushroom sample, 1 Kjeldahl catalyst tablet, and 10 mL of concentrated H, SO„ . Until a clear, colourless solution remained in the digestive tube, the digestion was left on for four hours. After completely cleaning the digestion tube with distilled water and making up the capacity of the flask with distilled water, the digested product was carefully transferred into a 100-mL volumetric flask. After pipetting it into a distillation device, 5 ml (m/v) of 40% NaOH was added. After the mixture was steam-distilled, the ammonia that was released was collected in a 50 mL conical flask with 10 mL of an indicator solution and 2% boric acid. The green colour solution was then titrated against 0.01 mol/L HCl solution.

Crude Protein Content (%) = micro-Kjeldahl nitrogen content (%) × 6.25
(Based on the assumption that nitrogen constitutes 16% of protein)

Estimation of potassium (Vogel, 1961)

Potassium was measured by flame photometry wherein 2 ml of the previously digested sample was removed and a volume of 50 ml was generated using distilled water. The amount of potash was ascertained after calibrating the flame photometer using the reference solutions (0 ppm, 5 ppm, 10 ppm, 20 ppm, and 40 ppm).

Estimation of sodium (Vogel, 1961)

Through flame photometry, sodium was calculated wherein 50 ml of distilled water were added to 2 ml of the previously digested sample. After calibrating the flame photometer with standard solutions (100 ppm, 80 ppm, 60 ppm, and 40 ppm), the amount of sodium was calculated.

Estimation of calcium, iron, zinc and magnesium (James, 1995)

The macro and micronutrient composition of different preservation methods of button

mushrooms and oyster mushrooms was determined. The elements in the mushroom samples were found using the atomic absorption spectrophotometer (PerkinElmer, PinAAcle 900°F) according to the AOAC (1990) procedure. The components in question were zinc (Zn), iron (Fe), calcium (Ca) and magnesium (Mg). SyngistixTM for AA, a workflow-based program created to expedite and streamline the process from sample to results for a variety of atomic absorption techniques, is in charge of operating the PinAAcle 900°F.

RESULTS AND DISCUSSION

Time Required for Sun-drying preservation

An investigation was carried out to find out time required to preserve two distinct edible mushrooms- the Oyster mushroom (*Pleurotus ostreatus*) and the Button mushroom (*Agaricus bisporus*)- by sun-drying them. The results in Fig. 1 show that button mushrooms require less time to prepare than oyster mushrooms.

Sundry preservation for the button mushroom was done from April 13, 2024 to April 22, 2024. During this time period of Sundry preservation an average maximum temperature was 33.44°C, minimum temperature 21.77°C, relative humidity 69.6%, an average rainfall of 1.44 mm, and an average sunshine hour of 4.13 hours was recorded. The Sun-drying process of oyster mushrooms started from May 20, 2024, and ended on May 29, 2024. The average maximum temperature and minimum temperature over this time span were 35.47º and 25.22ºC, respectively. The average relative humidity was 75.5%, and the average amount of rainfall and sunshine hours were 4.96 mm and 4.67 hours, respectively. During the process of Sundry preservation of Oyster mushroom and Button mushroom all the weather parameters was taken into consideration. Even though oyster mushrooms had a high average sunshine hour, it took longer time to dry due to high RH and high rainfall, on the other hand button mushrooms dried more quickly.

Time Required for Micro-wave Drying preservation

The goal of the experiment was to determine how long it would take to preserve two distinct edible mushrooms- the oyster mushroom (*Pleurotus ostreatus*) and the button mushroom (*Agaricus bisporus*) by microwave drying. This technique was tested on a 900 watt microwave for 9 to 14 min. In Table 1 shows that during this time, improper drying was evident in 9 and 10 minute processes, proper drying was evident in the 11 min, 12 min, and 13 min processes, and over drying was evident in the 14 min procedure. The results of the experiment, which are shown in Fig.2 demonstrate that oyster mushrooms require 12 minutes, while button mushroom samples require less time (11.67 min).

According to the study for microwave drying preservation of oyster mushroom and button mushroom, Button mushroom require less time to bake then that of oyster mushroom. Same time was recorded for proper drying in case of both oyster and button mushroom (Walde *etal*.2006: Giri& Prasad, 2007; Bhattacharya*et al*. 2015).

Nutrient (%) Content

The data presented in Fig.3 and Fig. 4 demonstrate a gradual decline in nitrogen (%) and protein (%) content for both Oyster and Button mushrooms, with microwave drying leading to a more significant nutrient loss compared to sun-drying. This suggests that while both thermal preservation methods result in nutrient degradation, microwave drying appears to cause greater reductions in these essential macronutrients(Bhattacharya *et al*. 2015; Pisko*et al*.2020; Süfer*et al*. 2017; Kalaè, 2009). Similarly, as shown in Fig. 5, the potassium (%) content in both mushroom types shows a steady decrease over time, although the rate of decline remains relatively consistent between the two drying methods. A similar trend is observed for sodium (%) content, as depicted in Fig.6, where both Oyster and Button mushrooms exhibit a gradual reduction. Fig.7 highlights that iron (%) content in Button mushrooms experiences a more pronounced decrease during both preservation methods, indicating that this particular nutrient is more susceptible to the thermal drying process (Kalaè, 2009;Ouzouni and Riganakos, 2007). Zinc (%) content, as shown (Fig. 8), decreases at a faster rate in Oyster mushrooms compared to Button mushrooms, but for both species, zinc levels

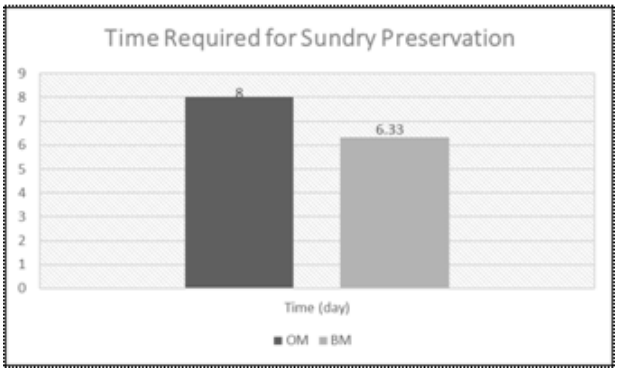


Fig. 1 : Time required for Sun-drying Preservation

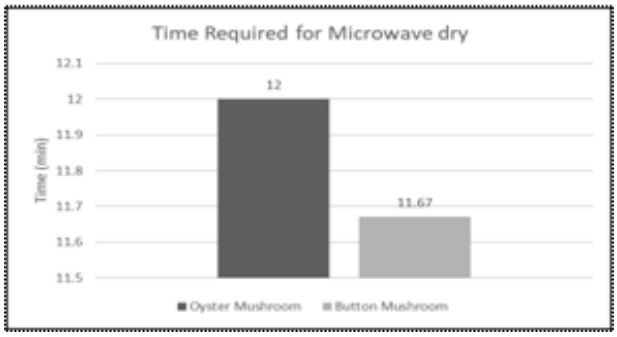


Fig. 2 :

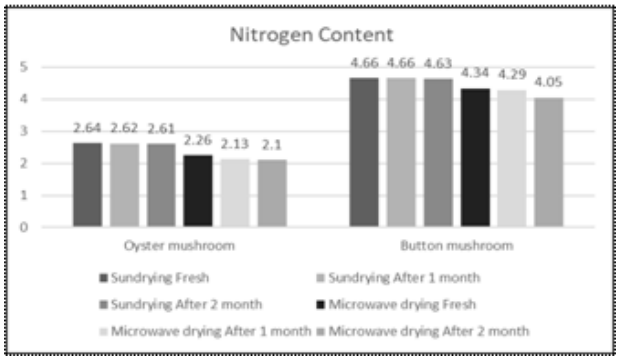
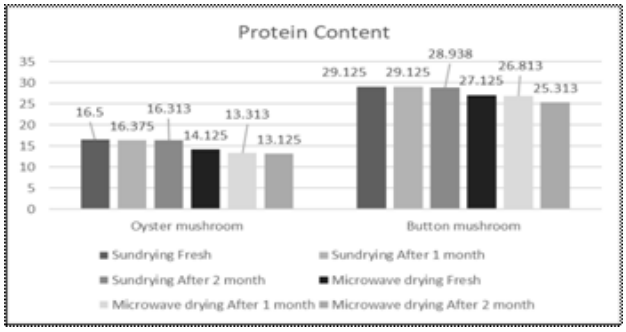


Fig. 3 :



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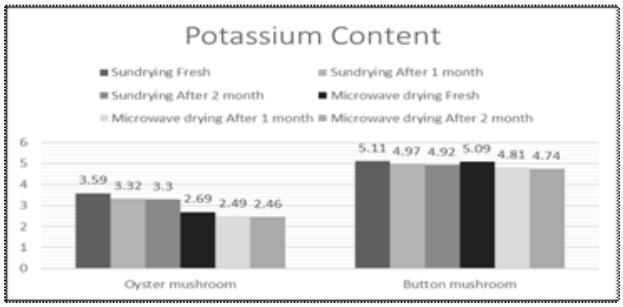

Fig. 5 :

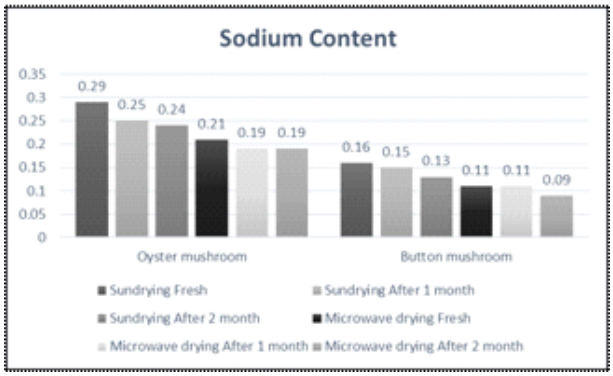

Fig. 6: Sodium (%) Content of Different Mushrooms for Thermal Preservation Methods

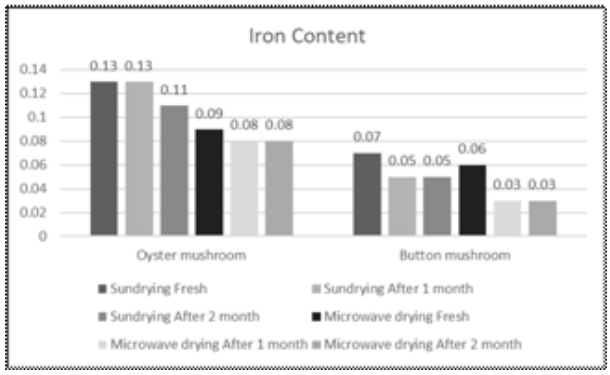

Fig. 7: Iron (%) Content of Different Mushrooms for Thermal Preservation Methods

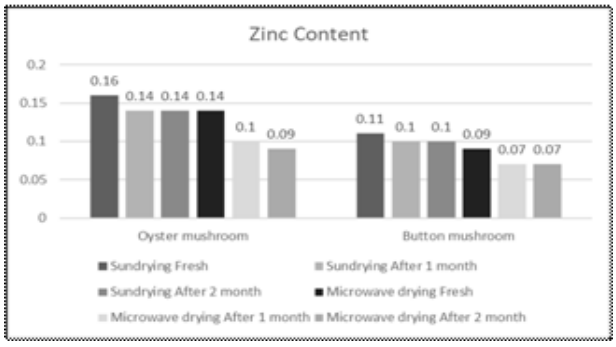

Fig. 8: Zinc (%) Content of Different Mushrooms for Thermal Preservation Methods

initially drop and then stabilize over time. The calcium (%) content, illustrated in (Fig.9), gradually declines for both mushroom types as the drying process continues, although the rate of reduction is not as steep (Mishra *et al*. 2016; Süfer *et al.*2017). Finally, Fig.10 shows that magnesium (%) content remains relatively stable with sun-drying, suggesting that this method

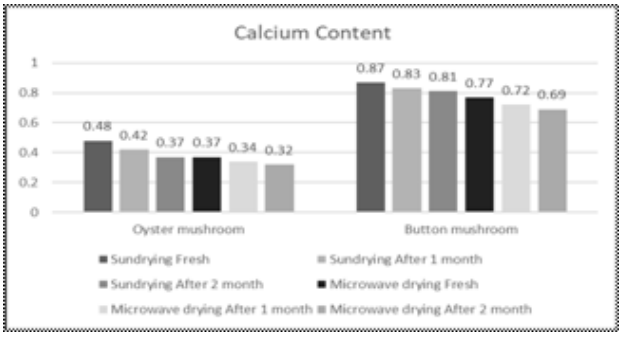

Fig. 9:

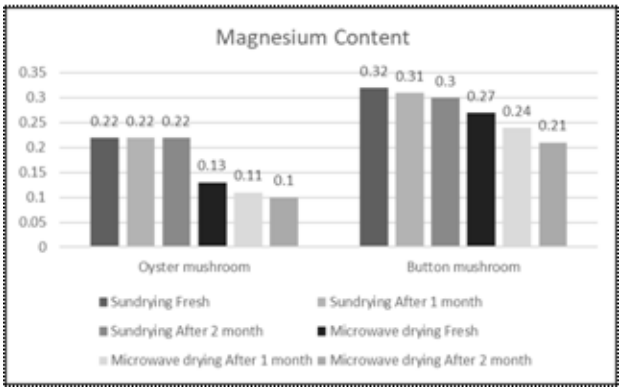

Fig. 10:

and several minerals, which show a more pronounced decline during microwave drying for both Oyster and Button mushrooms. On the other hand, sun-drying appears to have a much gentler impact on the nutrient levels of both mushroom species, with nutrient content remaining almost unchanged throughout the preservation process. In comparison between the two thermal preservation methods, sun-drying emerges as the more effective technique for maintaining the nutritional integrity of the mushrooms. The gradual, controlled drying process at low temperatures in sun-drying helps preserve essential nutrients more efficiently than the faster, more intense microwave drying method, making sun-drying the superior choice for thermal preservation of both Oyster and Button mushrooms.

Table 1: Time required for Microwave drying

Preservation Methods				Micro-wave drying (min)					
				9	10	11	12	13	14
Oyster mushroom				Improper drying	Improper drying	Proper drying	Proper drying	Proper drying	Over drying
Button mushroom	Improper drying	Improper drying	Proper drying	Proper drying	Proper drying	Over drying			

preserves magnesium levels more effectively. In contrast, microwave drying results in a gradual decrease in magnesium content, further emphasizing the difference in nutrient retention between the two preservation techniques (Tolera and Abera, 2017;Piskov*et al.* 2020).

CONCLUSION

Nutrient losses occur more significantly with microwave drying compared to sun-drying, as the data indicates a greater reduction in nutrient content when mushrooms are preserved using microwave drying. This is particularly evident in the case of key nutrients such as nitrogen, protein,

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DECLARATIONS

Conflict of Interest. Authors declareno conflict of interest.

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