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Effects of Drying on the Nutritional Value of Three Edible Mushrooms Grown in Nigeria

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ABSTRACT

Mushrooms are highly nutritious foods but are very perishable because of their high moisture content making preservation essential to extend shelf life and maintain quality. This study examined how drying affected the nutritional makeup of three edible wild mushrooms cultivated in Nigeria: Medical mushroom, White Oyster Mushroom, and Grey Oyster Mushroom. The mushrooms were dried, ground into powder, and analyzed for proximate composition, mineral content, and vitamin content using standard Association of Official Analytical Chemists (AOAC) methods. One-way analysis of variance (ANOVA) was used to evaluate the data, and the Duncan Multiple Range Test was used to differentiate mean differences at $p < 0.05$. The findings showed that the nutritional makeup of the dried mushrooms varied significantly. Grey oyster mushroom had significantly higher protein, crude fibre, fat, and ash contents, while medical mushroom recorded the highest carbohydrate and mineral contents. Vitamin analysis showed that medical mushroom contained significantly higher levels of vitamins A, C, B_2, and B_3, whereas vitamin B_1 was highest in grey oyster mushroom. White oyster mushroom generally had the lowest nutrient values. The study concludes that drying is an effective preservation method that significantly reduces moisture content and enhances shelf life while retaining most essential nutrients. The results support the rising use of dried wild edible mushrooms by highlighting their nutritional and therapeutic value in Nigeria for improved food security and human nutrition.

KEYWORDS: Nutrition, Dehydration, Post-harvest quality, Preservation method.

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BACKGROUND TO THE STUDY

Mushrooms belong to the class of higher fungi generally known as Basidiomycetes. Once referred to as the "food of the gods," edible mushrooms are still regarded as a delicacy or garnish and can be regularly consumed as part of a human diet, as a nutritious food, or as a functional food (Chang, 2017).

The lack of various methods for processing mushrooms is a result of their high moisture content (89–92%), which prevents them from being preserved for longer than two to three days at room temperature. Preservation techniques begin with a thorough analysis and understanding of the entire food chain, including growing, harvesting, processing, packaging, and distribution; therefore, an integrated approach must be used (Bradley, 2020).

Mushrooms are extremely perishable, just like fruits and vegetables (Bhal, 2014). The moisture content of mushrooms is 91.1%. It can be kept at 05ºC and 85–95% relative humidity for three to five days. Dehydration, canning, bottling, freeze drying, pickling, irradiation, and other techniques can all be used to preserve mushrooms (Bhal, 2014). The product undergoes several physico-

chemical changes throughout the drying process, which are frequently manifested in color, nutritional value, and functional behavior (Jimoh, 2019).

Nigerians are looking for edible mushrooms because of their nutritional benefits and palatability. The majority of them are sold in the market as dried mushrooms. Even while fresh mushrooms are ideal, their condition frequently requires that they be conserved for later use, especially if more are gathered than can be eaten at once. The two most popular methods for preserving mushrooms in most African countries are sun drying and drying over smoke.

This study's aim was to compare the effect of drying method on the nutrient contents of three wild edible mushrooms grown in Nigeria.

Specifically, the study intends to determine proximate contents, mineral contents and vitamin of the mushrooms.

MATERIALS AND METHODS

Three edible wild mushroom samples (Medical mushroom, White Oyster mushroom and Grey Oyster Mushroom) were collected from Hasef Mushroom Farm and Services, Kubwa, Abuja. The dried samples of three edible mushroom were dried and grounded into power form by using laboratory ceramic pounder, 5.0g of the powdered samples were weighted into beakers and the various proximate analysis were out as described below.

Determination of moisture content:

A clean crucible was dried to a constant weight in an air oven at 110°C, cooled in a desiccator, and weighed (Wl) using the procedure outlined by A.O.A.C. (1980). The previously labeled crucible was filled with precisely two grams of finely powdered sample, which was then reweighed (W2). The sample-containing crucible was dried in an oven until its weight remained constant (W3). This is how the % moisture content was determined:

$$\% \text{ Moisture content} = \frac{W2-W3}{W2-W1} \times 100$$

Where:

W1 = Initial weight of empty crucible

W2 = Weight of crucible + Sample before drying

W3 = Final weight of crucible sample after drying

Determination of ash content:

The A.O.A.C. (1980) approach was applied. The porcelain crucible was dried for ten minutes at 100°C in an oven, cooled in a desiccator, and then weighed (Wl). Two grams of the finely powdered material were put into a porcelain crucible that had been previously weighed and reweighed (W2), lit, and then placed in a furnace that was set to 550°C. To guarantee adequate ashing, the sample was kept in the furnace for eight hours. After that, the crucible holding the ash was taken out, cooled in a desiccator, and weighed (W3). This is how the percentage of ash content was determined:

$$\% \text{ Ash content} = \frac{W3-W1}{W2-W1} \times 100$$

Determination of crude lipid content by soxhlet method

300 cm3 of petroleum ether (40–60°C) for extraction was added to a clean, dried 500 cm3 round-bottom flask that had a few anti-bumping granules. The flask was then filled with a soxhlet extraction unit. The Soxhlet device was equipped with a twenty-gram extractor thimble. The Soxhlet extractor was attached to the round-bottom flask and a condenser, and cold-water circulation was activated. After turning on the heating mantle and adjusting the heating rate, the solvent began to reflux steadily. The extraction process took six hours. After recovering the solvent, the oil was dried for one hour at 70°C in an oven. Next, the oil and round-bottom flask were weighed (W2). This is how the lipid content was determined:

$$\% \text{ Crude Lipid content} = \frac{W2-W1}{Weight\ of\ Sample} \times 100$$

Determination of crude fiber

A 100 cm3 solution of 0.25 M sulfuric acid was added to a round-bottom flask containing 2g of sample, and the liquid was brought to a boil under reflux for 30 minutes. Under suction, the heated solution was rapidly filtered. The insoluble material was repeatedly cleaned with hot water until it was free of acid. After being quantitatively transferred into the flask, 100 cm3 of heated 0.31 M sodium hydroxide solution was added. The mixture was then cooked under reflux for 30 minutes before being filtered under suction.

The residue was dried to constant weight in an oven at 100°C, cooled in a desiccator, and weighed (Cl) after being cleaned with boiling water until it was base-free. After that, the weighed sample (Cl) was burned. Calculation: C1–C2 is the weight loss during incineration.

$$\% \text{ Crude Fibre} = \frac{C1-C2}{Weight\ of\ Sample} \times 100$$

Determination of protein

In this investigation, two distinct conical flasks containing one gram of each species of mushroom were filled with an equivalent volume of extraction buffer (20 mM Tris HCl dissolved in phosphate buffered saline). Centrifuge the mushroom at 5000 rpm for 10 minutes at 4–5°C after incubating it with the extraction buffer for 5–15 minutes.

Gather the supernatant after centrifugation and add an equivalent volume of ice-cold acetone. After centrifuging and incubating the solution at room temperature, gather the pellet and wash it with ice-cold acetone to get rid of the pigments. Lastly, the Lowry method was used to evaluate the protein concentration of various mushroom species.

Determination of carbohydrate by difference

The difference was used to calculate the total carbohydrate. According to Muller and Tobin (1980), the total percentage of moisture, ash, crude fat, crude protein, and crude fiber was deducted from 100.

Calculation:

% Total carbohydrate = 100 - (% moisture + % Ash + % fat + % Protein + % Fibre)

Mineral Analysis

At 550°C, samples were ashed. After boiling the ash in a beaker with 10 milliliters of 20% hydrochloric acid, it was filtered into a 100-milliliter standard flask. Deionized water was used to make up for this. The resultant solution was used to identify the minerals. The Standard Flame Emission Photometer was used to measure potassium (K) and sodium (Na).

The standards were KC1 and NaCl (AOAC 2015). Kirk and Sawyer (2011) used the spectronic 20 (Gallenkamp, UK) to measure phosphorus calorimetrically using KH2PO4 as the standard. The Atomic Absorption Spectrophotometer (AAS Model SP9) was used to measure calcium (Ca), magnesium (Mg), and iron (Fe). According to the Association of Official Analytical Chemists (AOAC) (2015), all values were given in mg/l00g.

DETERMINATION OF VITAMINS

Determination of Vitamin A

In a centrifuge tube, 1 mL of the sample and 1 mL of KOH were combined, agitated for 1 minute, then heated for 20 minutes at 60°C in a water bath. Following cooling, 1 mL of xylene was added, the tube was shaken once more for one minute, and it was centrifuged for ten minutes at 1500 g. The absorbance of the top layer of xylene was measured at 335 nm against xylene (A_1) in a sodium glass test tube. After 30 minutes of UV light exposure, the extract was subjected to another measurement of absorbance (A_2).

Calculate the concentration c_x of vitamin (μM) in the analysed liquid, using the formula:

$c_x = (A_1 - A_2) \cdot 22.23$

where:

22.23 – multiplier received on basis of the absorption coefficient of 1% solution of vitamin A (as the retinol form) in xylene at 335 nm in a measuring cuvette about thickness = 1cm (Rutkowk, *2016*).

Determination of Thiamine (Vitamin B_1)

The spectrophotometric approach outlined by Beelman (2014) was used to quantify the amount of thiamine (Vitamin B1). After homogenizing 5 g of each sample with 50 ml of 1 N ethanolic sodium hydroxide, the homogenate was filtered for examination. While a standard thiamine solution was made, diluted to 0.5 mg/ml, and treated identically with 10 ml of dichromate, a 10 ml aliquot of the filtrate was treated with an equal volume of 0.1 N potassium dichromate ($K_2Cr_2O_7$). Potassium dichromate was added to 0.5 ml of ethanolic sodium hydroxide to create a reagent blank. A spectrophotometer was used to measure the absorbance of both sample and standard solutions at 360 nm. The instrument was calibrated to zero using the reagent blank.

Thiamine content was calculated using formula:

$$\text{Thiamine } \frac{\text{mg}}{100g} = \frac{100}{W} \times \frac{Au}{As} \times \frac{C}{I} \times \frac{Vf}{Va} \times D$$

Where:

W	=	Weight of sample analyzed
A_u	=	Absorbance of sample
A_s	=	Absorbance of standard solution
C	=	Concentration (mg/ml) of standard solution
V_f	=	Volume of filtrate
V_a	=	Volume of filtrate analyzed
D	=	Dilution factor where applicable

Determination of Vitamin B_2 (riboflavin)

The AOAC (2015) method was used to measure the amount of vitamin B2 in the samples. A 201 ml volumetric flask was filled with precisely weighed 1.5 g of sample, 100 ml of a 50:50 acetic acid to water mixture, and heated to 100°C for 30 minutes in a boiling water bath. After cooling to 20°C, the mixture in the flask was adjusted with an acetic acid-water solution. After ten minutes of stirring with the stirrer, the mixture was filtered in the dark.

After discarding the first 20 milliliters of the filtrate, 0.5 milligrams of riboflavin standard solution were made, and 10 milliliters of the standard solution were put into a 201 milliliter volumetric flask and handled in the same manner as the previous sample. A spectrophotometer set to 460 nm was used to measure the fluorescence of the standard and sample solutions.

The amount of riboflavin in each sample was calculated as follows:

$$\text{Riboflavin (mg/100g)} = \frac{sample\ absorbance}{standard\ absorbance} \times \frac{weight\ of\ std(mg)}{weight\ of\ sample} \times 100$$

Determination of Vitamin B_3 (niacin)

Vitamin B3 content in the samples was determined using the AOAC (2015) method. A 1.5 g sample was accurately weighed into a 201 ml volumetric flask, to which 5 ml of 5 N hydrochloric acid and a mixture of 5 ml dichloromethane with 90 ml deionized water were added. The mixture was stirred and heated in a boiling water bath at 100°C for 30 minutes, then cooled and diluted to the mark with distilled water.

After passing the mixture through Whatman No. 1 filter paper, the first 20 milliliters of filtrate were discarded. A standard solution of niacin (0.5 mg) was made and handled in a similar manner. A spectrophotometer was used to measure the absorbance of the standard and sample solutions at 410 nm. The vitamin B3 content was then computed as follows:

$$\text{Niacin (mg/100g)} = \frac{sample\ reading}{standard\ reading} \times \frac{standard\ weight(mg)}{sample\ weight} \times 100$$

Determination of Vitamin C

To convert ascorbic acid to dehydroascobic acid, 0.23 mL of 3% bromine water was added to 4 mL of centrifuged sample solution. The surplus bromine was then removed using 0.13 mL of thiourea. Next, 1 milliliter of 2, 4-DNPH solution was added to the osazone. In a thermostatic bath, all standards, samples, and blank solution were maintained at 37°C for three hours.

Following a 30-minute cooling period in an ice bath, 5 mL of chilled 85% H_2SO_4 was added while stirring continuously. Consequently, the absorbance of a colored solution was measured at 521 nm. Kapur., *et al*. (2012).

Data analysis

Data obtained were analyzed using one-way analysis of variance (ANOVA), and mean differences were separated using Duncan Multiple Range Test at $p < 0.0$

RESULTS

Proximate Composition of Three Dried Wild Edible Mushrooms

Table 1 presents the proximate composition of dried mushrooms. Moisture content is significantly higher in white oyster mushroom compared to others. Grey oyster mushroom shows significantly higher levels of ash, fiber, fats, and protein than both white oyster and medicinal mushrooms, while medicinal mushroom has the highest carbohydrate content relative to white oyster and grey oyster.

Table 1: Proximate Composition of Three Dried Wild Edible Mushrooms

	Medical mushroom *(Ganoderma lucidum)*	White Oyster *(Pleurotus ostreatus)*	Grey Oyster *(Pleurotus sajor-caju)*
Moisture	3.65±0.07^a	7.57±0.04^c	5.34±0.08^b
Ash	4.23±0.04^a	6.05±0.07^b	6.98±0.04^c
Fibre	6.53±0.01^a	9.82±0.03^b	11.15±0.07^c
Fats	5.70±0.00^b	3.85±0.07^a	6.77±0.04^c
Protein	29.69±0.09^b	27.96±0.06^a	34.35±0.06^c
Carbohydrate	50.21±0.11^c	44.76±0.13^b	35.42±0.17^a

Values are Mean ± SD, Values with different superscript across the rows are considered statistically significantly different at $p<0.05$

Mineral Composition of Three Dried Wild Edible Mushrooms

Table 2 presents the mineral composition of dried mushrooms. Magnesium content is significantly higher in the medicinal mushroom compared to others. Additionally, the medicinal mushroom shows significantly higher levels of phosphorus, potassium, sodium, calcium, and iron than both white oyster and grey oyster mushrooms, while white oyster mushroom exhibits the lowest composition across all minerals.

Table 2: Mineral Composition (ppm) of Three Dried Wild Edible Mushrooms

	***Ganoderma lucidum* (Medical mushroom)**	**White Oyster *(Pleurotus ostreatus)***	**Grey Oyster *(Pleurotus sajor-caju)***
Na	192.07±0.05^{c}	148.20±0.14^{a}	168.55±0.21^{b}
K	337.60±0.28^{c}	294.50±0.14^{a}	320.60±0.14^{b}
Mg	427.40±0.14^{c}	360.15±0.21^{a}	401.15±0.07^{b}
Ca	170.40±0.00^{c}	101.60±0.14^{a}	133.50±0.00^{b}
Fe	23.05±0.07^{c}	10.45±0.21^{a}	16.15±0.21^{b}
P	390.40±0.00^{c}	314.75±0.07^{a}	350.60±0.14^{b}
Zn	27.45±0.07^{c}	18.50±0.14^{a}	22.05±0.07^{b}

Values are Mean ± SD, Values with different superscript across the rows are considered statistically significantly different at $p<0.05$

Vitamins Composition of Three Dried Edible Mushrooms

Table 3 presents the vitamin composition of the studied mushrooms, highlighting significant differences among the varieties. Medicinal mushroom exhibits significantly higher levels of vitamins A, C, B2 (riboflavin), and B3 (niacin) compared to both white oyster and grey oyster mushrooms, though vitamin B1 (thiamine) levels do not follow this trend and are not notably elevated in the medicinal type. White oyster mushroom consistently shows the lowest vitamin content across the board.

Table 3: Vitamins Composition of Three Dried Wild Edible Mushrooms

	Medical mushroom *(Ganoderma lucidum)*	**White Oyster *(Pleurotus ostreatus)***	**Grey Oyster *(Pleurotus sajor-caju)***
Vitamin A	38.89±0.01^{c}	29.32±0.03^{a}	31.23±0.00^{b}
Vitamin C	13.62±0.04^{c}	12.94±0.04^{b}	12.65±0.04^{a}
Vitamin B1	0.27±0.01^{a}	0.28±0.00^{a}	0.33±0.01^{b}
Vitamin B2	1.17±0.01^{c}	0.28±0.01^{a}	0.38±0.01^{b}
Vitamin B3	0.48±0.01^{c}	0.30±0.01^{a}	0.38±0.01^{b}

Values are Mean ± SD, Values with different superscript across the rows are considered statistically significantly different at $p<0.05$

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

Discussion

The chemical composition of mushrooms is influenced by a number of parameters, including substrate type, mushroom species, age, basidiomata portion, and post-harvest storage conditions (Adejumo and Awosanya, 2005). This study examined how drying affected the nutritional makeup of three edible wild mushrooms cultivated in Nigeria. Overall, the findings show that the mushrooms under investigation are a good source of phytochemicals, vitamins, minerals, and nutrients.

The Medical mushroom in this study has a high carbohydrate content, which is in line with findings for wild mushrooms in other regions of the world (Sanmee *et al*., 2003; Gbolagade *et al*., 2006; Saika *et al*., 2008).

A significant amount of this carbohydrate is dietary fiber, which has a low calorific value and acts as roughage. Furthermore, the presence of sugar alcohols indicates that these mushrooms could be a good alternative to high-energy sweets in diets for those with diabetes (Hamano, 1997).

With respect to proximate composition, the maximum moisture content observed in this study aligns with findings from previous studies and may be attributed to structural differences among mushroom species (Florkowski *et al*., 2009). The moisture content

of the dried Medical mushroom was lower than that reported for dried White oyster mushroom (Baloch *et al*., 2015) and Grey oyster mushroom (Kaur *et al*., 2008). The fat, ash, and fibre contents of the dried mushrooms were relatively low, which may be attributed to the effect of the drying method employed. Moisture content decreased significantly due to dehydration, a finding that corroborates the report of Ayodele *et al*. (2011), who also observed reduced moisture levels following mushroom drying.

In every dried sample, the amount of carbohydrates increased with the highest increase recorded in the Medical mushroom. Similar increases in carbohydrate content after drying have been reported by Barros *et al*. (2008) in other mushroom species.

The findings of this study are consistent with those of Oni *et al*. (2015), who reported high protein content in oven-dried *Telfairia occidentalis*, *Talinum triangulare*, and *Amaranthus hybridus*.

The protein levels for oven-dried *Moringa oleifera* leaves published by Alakali *et al.* (2015) are similarly consistent with the results of this investigation. Protein is a vital component of the human diet, required for tissue repair, growth, and energy supply, as well as for providing essential amino acids. Growth retardation, muscle atrophy, oedema, aberrant body swelling, and fluid buildup are all consequences of protein shortage, especially in children (Mounts, 2000).

The study's dried mushrooms had greater carbohydrate content than the dried cauliflower reported by Baloch *et al*. (2015). Additionally, according to Oulai *et al*. (2016), the ash content of shade-dried *Hibiscus sabdariffa* and *Amaranthus hybridus* was lower than the ash content found in this study. One key measure of the overall mineral makeup of food is its ash content.

Among the mushrooms studied, Medical mushroom exhibited the highest magnesium concentration compared to Grey oyster and White oyster mushrooms. The results of Chang and Miles (2019), who found that the content of magnesium in mushrooms varies greatly among species, are consistent with this fact.

Vitamins A, B2, and B3 were present in relatively high amounts in the Medical mushroom. Since mushrooms provide appreciable quantities of B-group vitamins as well as essential minerals such as selenium, potassium, copper, and zinc, they are considered nutritious, low energy-dense foods (Feeney *et al*., 2014; McCance and Widdowson, 2015).

Conclusion

Conclusively, proximate analysis of nutrient of three dried edible mushrooms showed that drying affects nutrients composition of mushrooms. Medical mushroom is highly medicinal due to it very high mineral content. Oyster mushroom is highly nutritious due to it high concentration of protein, fibre and fat. Low moisture content of dried mushrooms suggests that drying extends the shelf life of mushrooms best and retains most of the nutrients.

Recommendations

(1) Due to their hygroscopic nature, dried mushrooms can be stored in a variety of packaging materials and environments.
(2) The dehydration process can be mathematically modeled at different temperatures, dryer types, pre-treatments, and air velocities.
(3) It is also possible to investigate how different process conditions affect the retention of nutrients in mushrooms.

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