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Production and nutritional composition of juice powder from oyster mushroom *Pleurotus ostreatus* (Jacq.) Kummer

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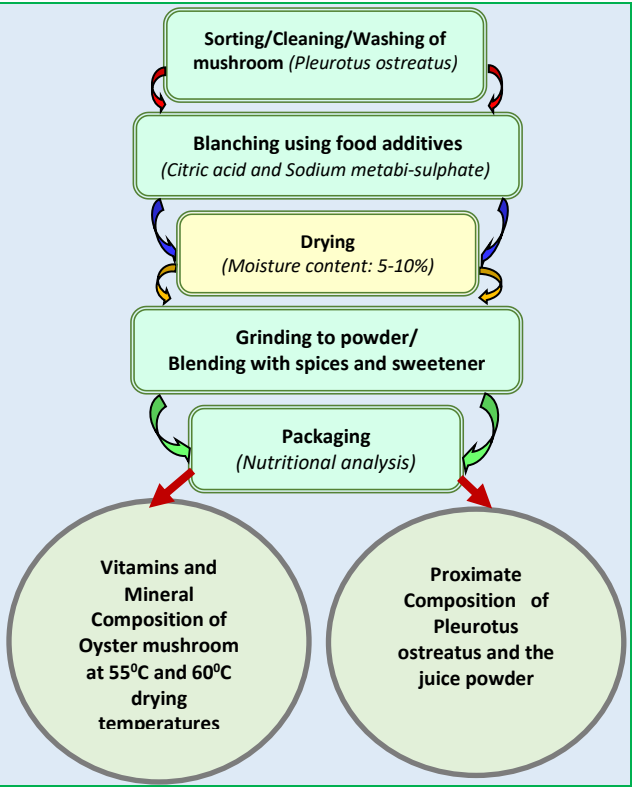
ABSTRACT

Background: Mushrooms have been used as functional foods, nutraceuticals and medicines for decades in Asian countries. Because of their vital roles in human health, nutrition, and well-being, they are described as treasures in the wild and have served as food supplements. In regard to their nutritional composition, they are relatively low in total fat, vitamins, minerals, and fiber, but rich in high quality proteins and polyunsaturated fatty acids.

Objective: To determine the nutritional value and proximate analysis of the oyster mushroom *Pleurotus ostreatus,* formulate mushroom juice powder, and determine its nutritional composition of the powder

Methods: Optimization of the processing condition of the mushroom *Pleurotus ostreatus* (Jacq.) Kummer



was first conducted using four different drying temperatures; 55°C, 60°C, 65°C and 70°C hourly for 3 hours to determine the best drying temperature. The temperatures at which the juice retained 5-10% moisture were selected for preparation of condensate and analysis because they had the best nutrient composition. Stevia (plant sugar) was used as a sweetener and ginger as the flavor for the formulation of the juice powder. A nutritional composition analysis of the juice powder was also carried out.

Results*:* The nutritional composition of dried *P. ostreatus* at the chosen drying temperature (55 °C) were (8.71, 9.45, 7.07, 9.38, 51.81 and 13.3 mg/g) for iron, manganese, copper, zinc, magnesium and calcium respectively. Nutritional values Fe, Mn, Cu, Zn, Mg and Ca for the juice powder were 8.96 mg/g, 12.1mg/g, 7.94 mg/g, 11.88 mg/g, 59.0 mg/g and 42.0 mg/g respectively. The vitamin content of initial P. *ostreatus* raw material were Vitamin B1 (4.99) and B6 (0.74) while for the juice powder B1, B6 and C were 0.78mg/g, 0.035mg/g and 0.21mg/g respectively. Proximate analysis showed that the mushroom contained moisture (11.20±0.47%), fat (0.55±0.07%), protein (39.75±0.53%), fiber (3.30±1.04%), ash (8.65±0.52%) and carbohydrate (36.54±0.50%) while juice powder contained moisture (5.0%), fat (1.0%), protein(27.13%), fiber (16.00±2.52%), ash (2.83±0.12%) and carbohydrate(48.04±2.58%).

Conclusion: This work demonstrated that the nutrient composition of the mushroom improved when formulated into juice powder. The quantity of Zn and Ca significantly increased in the juice powder at $p<0.05$ and reached the recommended daily dietary allowances and adequate intakes.

Keywords: *Pleurotus ostreatus,* Juice powder, Nutritional value, formulation

INTRODUCTION

Mushrooms are fleshy fungi forming an umbrella-like fruiting body. They do not have green chlorophyll and therefore do not manufacture their food. Mushrooms have microscopic spores, which is a means of reproduction. They are widely distributed in temperate and tropical regions, and it actually take days or weeks for one to grow, develop and mature [1, 2]. Mushrooms have been used as diets, nutraceuticals, and drugs for years in Asian countries [3, 4]. Mushrooms are known as one of the most vital diet enhancements for their important roles in human health, nutrition, and various diseases. They consist of many bioactive compounds, including primary metabolites that could avert oxidative stress [5] as well as secondary metabolites such as polysaccharides (mainly β-D-glucans), heteroglycans, chitinous substances, peptidoglycans, proteoglycans, lectins, RNA components, lectins, lactones, alkaloids, terpenes, flavonoids, terpenoids, steroids, phenols, glycoproteins, nucleotides, fatty acids, vitamins, proteins, amino acids, antibiotics and minerals that have positive impacts on the human body and protect it from the diseases [4, 5]. These bioactive compounds are superb antioxidants and anti-inflammatory agents beneficial to the central nervous system, heart, kidney, and liver [6]. Also, it has been proven that these bioactive compounds act as chemopreventive agents and prevent most serious

diseases, including diabetes, obesity, CVD, and neurodegenerative diseases [7].

Nutritional analyses found that edible mushrooms contain vital nutrients and have good taste, flavor, and some physiological functions [8]. They are rich in high-quality proteins, polyunsaturated fatty acids (with a relatively low content of total fat), vitamins, minerals, and fiber. Mushrooms produce low energy which is good for weight loss, contain low glucose and high mannitol, which is good for diabetics, and has no cholesterol and low sodium, which is good for people suffering from hypertension [6, 8]. Furthermore, mushrooms have a high content of vitamin D and B-complex with a high content of minerals and a significant quantity of many trace elements, especially of selenium, which is a potent antioxidant [9].

In addition to their nutritive value, edible mushrooms have unique features in terms of color, palate, flavor, odor, and texture that make them more attractive for human ingestion. Several studies have recommended regular ingestion of certain mushrooms either as a regular food or as extracted compound (nutraceuticals). Some of these compounds (polysaccharides) are active in both preventing and treating various diseases [8]. The high content of natural sugars in 100% fruit juice may cause health complications similar to juice containing synthetic sugars, as the natural sugars are broken down and absorbed as glucose and fructose, which is the same as juice containing artificial sugars [10]. Fresh mushrooms are highly perishable with short shelf life under ambient environment, temperature, and humidity, making their commercialization difficult. Among the various techniques employed for the conservation of mushrooms, drying seems to be an effective approach to extend shelf life and ensure distribution [11-12]

There seems to be no report of powdered juice formulated with *P. ostreatus* grown in Nigeria and its nutritional value. This paper reports the process of production of juice powder from oyster mushroom and its nutritional composition.

MATERIALS AND METHODS:

Sample collection: The oyster mushroom was collected from the Mushroom Research and Training Laboratory at Yaba College of Technology, Lagos. The plants used as a sweetener (*Stevia rebaudiana*) and as flavor (*Zingiber officinale*) were bought from a local (Yaba) market.

Optimization of processing condition: Four different samples of the mushroom, each weighing 150g were dried using a dehydrator (Daewoo, Yuyao Ouyou Electric Appliance Technologies, Co. Ltd) at temperatures (55^{o}C, 60^{o}C, 65^{o}C and 70^{o}C) for 3 hours. The samples for each temperature were divided into three, and 50g of each sample was dried using a dehydrator. Initial moisture content and relative humidity at intervals of 1hr were determined for 3 hours. Samples with 5-10% moisture content were analyzed based on their minerals and vitamin composition to determine the best drying temperature to use for further work.

Preparation of juice powder using oyster mushroom: Mushroom (200g) was sorted, cleaned and washed after which it was blanched using citric acid and sodium metabisulphite, drained and dried at optimized temperature and time using a dehydrator. The dried mushroom was blended to powder, and

then mixed with 30g of stevia (plant sugar) and 10g ginger powder (Fresh ginger was dried, ground and sieved to remove fiber). Proximate analysis was done on the mushroom and the juice powder from the mushroom.

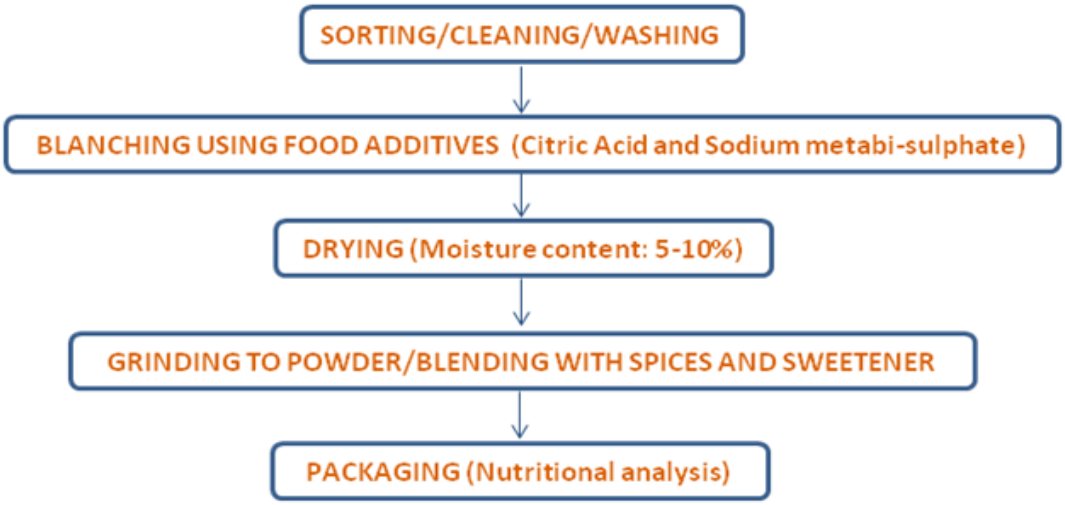


Figure 1. Production flow chart for the preparation of juice powder using *Pleurotus ostreatus*

Determination of Crude Fat: Crude fat was determined by the solvent extraction method [13]. Juice powder (10g) and dried powdered mushroom (10g) were weighed and transferred into 3 different beakers and 50ml petroleum ether was added to each of the beakers and left for 1 hour in the fume cupboard and swirled occassionally. The petroleum ether was then decanted into an empty petri dish and allowed to evaporate. This process was repeated for the other two samples. The Petri dishes were weighed after evaporation and the weight of fat was calculated. The percentage of crude fat content was also calculated.

Weight of fat = Weight of petri dish after evaporation – the weight of empty petri dish

Determination of Crude Fiber: Total amount of fiber was determined using the AOAC method [14]. The defatted samples were weighed and put into a flat bottom flask. H_2SO4 (50mL) was added, and the mixture was boiled for 30 minutes after which it was sieved, washed with distilled water, and put back into the flat bottom flask. KOH (50mL) was added to the residue, and the mixture was boiled for another 30 minutes, sieved and washed with distilled water. The residue was put into a beaker containing 10ml of acetone, and left for 20 minutes and then filtered. The samples were dried in the oven for 30 minutes at 130^{o}C.

Determination of Total Ash: The total amount of Fiber was determined by using AOAC method [14]. Residues from the crude fiber were weighed into porcelain crucibles which were previously ignited and weighed. The crucible was placed in a muffle furnace, which was maintained at 55 ºC for 6 hours. It was then

cooled in a desiccator until ash is obtained and weighed, and the ash content was calculated afterwards [14].

Determination of Crude Protein: Crude protein was determined using the modified Lowry method [15]. Defatted residues (1g) each were soaked with 5ml of phosphate buffer in sample bottles and then put in the freezer for 1hr. 1ml of each filtrate was put in 2 different test tubes and 1ml of buffer was tested as a blank. 3ml of reagent 1 was added to each of the test tubes and incubated at room temperature for 10 minutes after which 0.1ml of reagent 2 was added to each test tube and incubated at room temperature for 30 minutes. Absorbance was taken at 750nm wavelength.

Reagent 1: 48ml of Lowry's solution Na2CO3 + 1 ml of NaK + 1ml of

Reagent 2: 1ml of Folinsocateur + 4ml of water

Determination of Total Carbohydrate: The total carbohydrate was determined by the difference method [16]. It was calculated with the following equation:

Crude Carbohydrate (%) = [100 − (%Total moisture + %Crude protein + %Crude fat + %Crude fiber + %Total ash)]

Vitamin C Content Determination: The modified method of [17] was used in the determination of ascorbic acid content. Juice powder (1g) and dried powdered mushroom (1g) were each dissolved in 25ml of 0.025M of phosphate buffer pH 3 and kept in the freezer for 30 minutes, after which it was centrifuged at 4000rpm for 10 minutes. The filtrate was decanted into a sample bottle and then filtered with a micro-filter into another plastic bottle for HPLC analysis. The working condition of HPLC was as follows; HPLC detector: Agilent VWD detector: 254um, column: Zorbax Eclipse XDB C18 4.6×100mm, 3.5um, Mobile phase; CAN phosphate buffer pH 3(10:90) %, Flow rate: 0.8ml/min, Temperature: Ambient.

Mineral Content Determination: Using the modified method based on APHA 3030A, 2017, mineral content was determined using the acid digestion method. Sample (1g) each was weighed accurately into a conical flask using Sartorius analytical balance and 10 ml of HNO_3 (Nitric acid) were added in a fume cupboard. The mixture was heated on a hot plate, giving off brown fumes, and left to heat until all the brown fumes were given off. The conical flask was removed from the hot plate and allowed to cool. Distilled water (20mL) was added to the content of the conical flask and then returned to the hot plate and allowed to boil to bring the metal into solution. The solution was allowed to cool and filtered into a 100ml volumetric flask using Whatman 42 filter paper. Distilled water was used to mark up to 100ml and then decanted into 100ml sample plastic for instrumental analysis. The minerals were evaluated through atomic absorption spectrophotometry [18] using atomic absorption spectrophotometer (AAS) 200 series (Agilent Technologies) Wald brown Analytical Div. B4, Germany.

Statistics and Analysis: Data collected from all experiments are expressed as mean ± standard using IBM SPSS statistical package. Deviation (SD) at a 5% level of significance.

RESULTS AND DISCUSSION:

Figure 2 shows the final weight and relative humidity of oyster mushroom at different drying temperatures conditions.

The result presented in Figure 2 shows the final weight and relative humidity of mushroom at different times and temperatures. Oyster mushroom dried (50g) at 55°C, 60 °C, 65 °C and 70 °C for 3hrs had final weights of 8.5g, 7.8g, 8.8g and 7.0g, respectively. The relative humidity for 55°C was 54%, relative humidity at 60°C (69%), 65°C (53%) and 70°C (60%). This result showed that relative humidity varied at each drying time and temperature, there was no consecutive increase or decrease in relative humidity.

Comparing the final weight and relative humidity of *P. ostreatus*, the results presented in Figure 2 shows that the final weights were non-significantly different at different temperatures. Likewise, relative humidity showed no significant difference. Theweight of the mushroom reduced exponentially with temperature increase, so drying temperature had a significant effect on the moisture removal from the mushroom which was similar to the report of [19]. The relative humidity was reduced with an increase in temperature but not consistent with time [20]. Kulshrehlha et al*.,* [21] also reported that the drying rate increased with an increase in temperature.

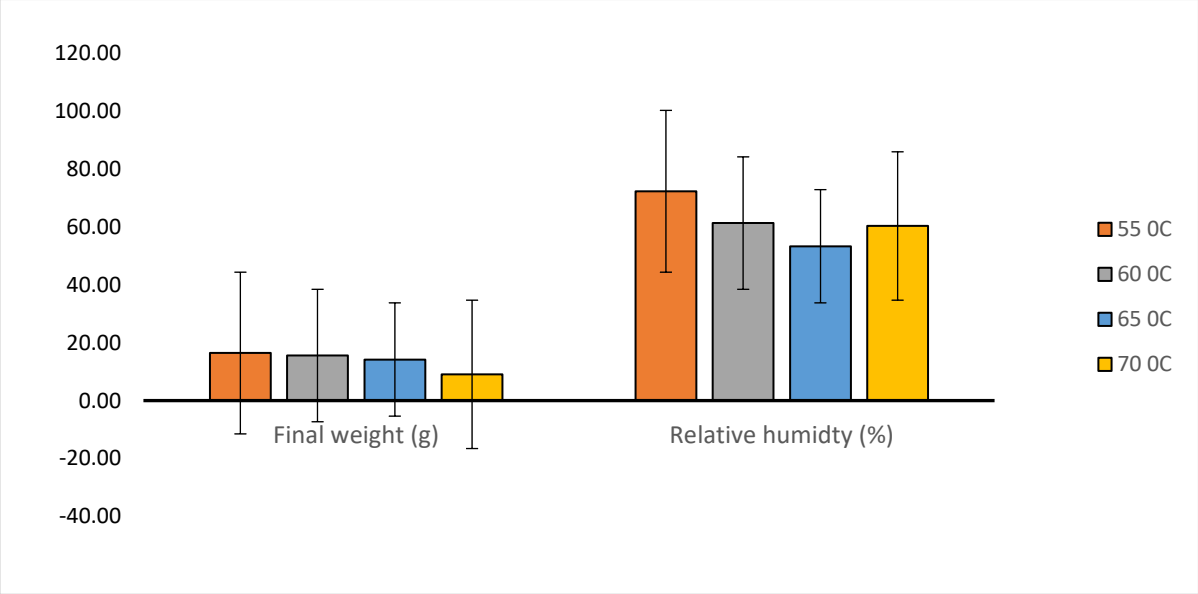


Figure 2. Final weight and relative humidity of oyster mushroom at different drying temperatures (Mean ± SD)

Table 1 shows the mean pattern of the oyster mushroom dried at different temperatures conditions.

Moisture Content: The result presented in Table 1 shows the moisture content at different times for the different drying temperatures. At 1 hour, oyster mushroom dried at 55°C, 60°C 65°C 70°C with moisture contents of 65%, 55%, 55% and 35%, respectively. For 2 hours drying for the different temperatures, moisture contents were 28%, 13%, 10% and 13%, respectively. At 3hours, 65°C and 70°C had no moisture while 55°C and 60°C had 5% moisture. The rate of moisture reduction increased as

temperature increased from 55°C to 70°C which aligned with [20]. Water content affects food quality, it provides a medium to support microbial growth. Generally speaking, the more water that is present, the greater the opportunity for microbes to grow [22], as regards this, 65°C was eliminated due to the high moisture content of 10% which would decrease the shelf life of the mushroom. Drying air temperature of 50°C is better as it gives dried products with higher rehydration ratio, lower shrinkage and better color [21].

The moisture content of the mushroom per dry weight non-significantly decreased with increased temperature but constant at 60°C and 65°C although the initial moisture contents for the temperature were not the same. It was evident that higher temperatures increased the drying rate for the mushrooms [19].

Table 1: Mean Moisture pattern of oyster mushroom at the different drying temperature and time

	MOISTURE PATTERN (%)			
TIME/ TEMP	0HR	1HR	2HRS	3HRS
55°C	70	65±0.0	28±10.6	5±0.0
60°C	60	55±0.0	13±3.6	5±0.0
65°C	70	55±0.0	10±0.0	0±0.0
70°C	75	35±0.0	13±3.5	0±0.0

Values reported are mean± standard deviation n=2

Figure 3 shows the vitamins and Mineral Composition of Oyster Mushroom *Pleurotus ostreatus.*

The result presented in Figure 3 shows the vitamins and mineral composition of oyster mushroom dried at 55°C and 60°C for 3 hours. Magnesium had the highest value of 55.81 mg/g dry weight while vitamin B6 had the least value of 0.79 mg/g /dry wt. Mineral contents were higher in the juice powder than in the dried mushroom at mg/g dry weight. Magnesium had the highest content in both the dried mushroom and juice powder (51.81 and 59.0 mg/g dry wt.) followed by calcium (13.30 and 42.0 mg/g dry wt.), respectively. This result is in line with Mallikarjuna *et. al.,* [23]. Four different species of mushroom were reported as good sources of magnesium at mg/100g dry weight [23]. Juice powder had a higher content of zinc than the dried mushroom (11.88 and 9.38 mg/g dry wt.), respectively. Good content of zinc was also reported for *Pleurotus djamor* and *Lentinus edodes* with 9.21 and 9.44 mg/100g dry wt. [23]. Mushrooms are known as good accumulators of zinc, which is very vital to the human body [24] for the strong immune system, wound healing, and sense of smell.

The values of Cu, Zn, Mg and Ca were higher in the mushroom dried at 60°C but Fe, Mn, vitamin B1 and B6 were non-significantly higher at a drying temperature of 55°C, possibly because higher temperature affects the mineral content of the mushroom.

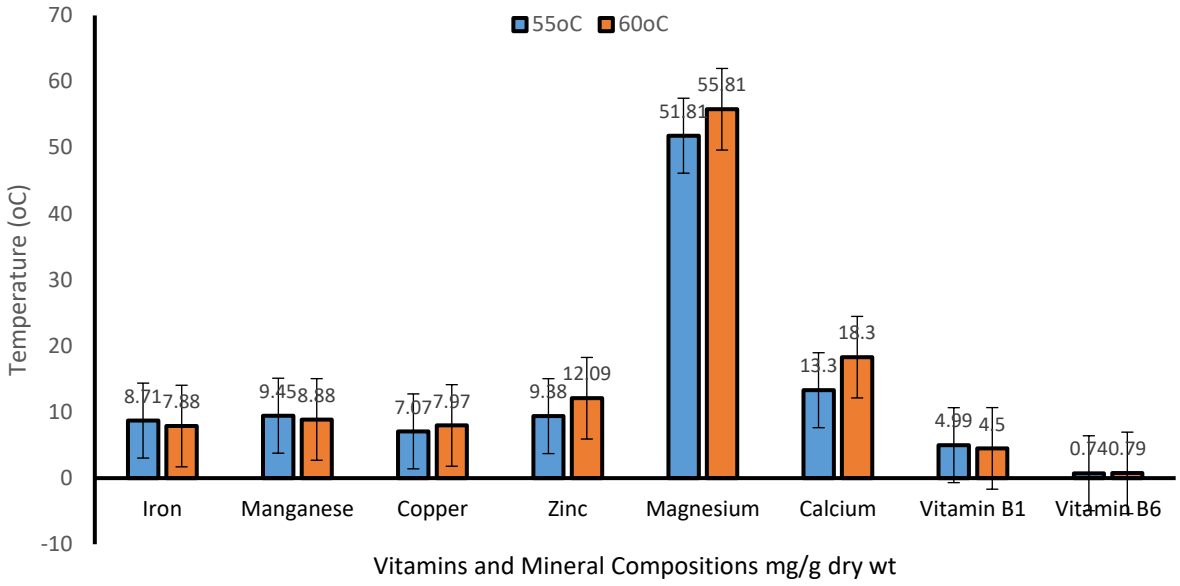


Figure 3: Vitamins and mineral composition of oyster mushroom at 55°C and 60°C drying temperatures

The result represented in Table 2 shows the vitamin and mineral composition of the juice powder, the recommended daily intake of the minerals and vitamins, and % daily value for juice powder.

The dry weight of iron was 8.96mg/g. which was 29.9-32% of the recommended daily intake of iron. Mn, Cu, Zn, Mg and Ca contents in the juice powder were 12.1%, 7.94%, 11.88% 59.0%, 42.0% recommended daily intake of the minerals for adults [25]. The value of vitamin B1 was 4.99mg/g for the mushroom dried at 55°C and 4.50mg/g at 60°C which is in line with the work done by Celen et al.[19] in that higher temperature increases the risk of losing vitamins in mushrooms (Fig. 2). Table 2 shows that some of the minerals (Mg, Cu, and Zn) in the juice reached the recommended daily dietary allowances and adequate intakes for adults [25].

Table 2: Vitamin and mineral composition of juice powder with a daily recommended value

Nutrients (mg/g)	Juice Powder (55°c)	Recommended Daily Value (mg/day)	% Daily Value For Juice Powder
Iron	8.96±1.12	28-30	29.9-32
Manganese	12.10±1.01	5.5	220
Copper	7.94±0.11	2.2	360
Zinc	11.88±0.21	15.5	76.6
Magnesium	59.00±1.40	360	16.4
Calcium	42.00±1.00	1000	4.2
Vitamin B1	0.78±0.30	1.4	55.8
Vitamin B6	0.04±1.10	1.9	1.8
Vitamin C	0.21±0.11	85	0.25

Further processing could have affected the vitamin content of the juice powder because the vitamin B1 and B6 content in the mushroom (4.99 and 0.74 mg/g dry wt.) were higher than in the juice powder (0.781 and 0-035 mg/g dry wt.). A similar report was given by Mbuge and Mutai [26], stating that nutrient losses come from different steps in the process of drying also that elevated temperature degrades vitamins.

The temperature of 60°C has been reported as suitable for drying edible mushrooms as it preserves most nutritional values [26,27]. The report is in line with the results of the present study which recorded 55°C and 60°C preserved most of the nutrients in the mushroom and the juice powder. 55°C was chosen for the formulation of the juice because a lower temperature with 5% moisture content was preferable. Cu and Mn reached the recommended daily intake [28] Recommended daily intake (RDI) was as reported by the Indian Council of Medical Research [28].

Figure 4 shows proximate composition of the oyster mushroom and Juice Powder.

The result presented in Figure 4 shows the proximate composition of the *Pleurotus ostreatus* and juice powder which showed that moisture, fat, protein, fiber, ash and carbohydrate contents were 5.0%, 1.0%, 27.13%, 16.0±2.5160%, 2.83±0.1155% and 48.04±2.5813%,respectively, for the juice powder, and 11.2%, 0.55%, 39.75%. 3.3%, 8.65% and 36.54%, respectively, for the dried mushroom. Low-fat content was also recorded in the dried mushroom and the juice product confirming that mushroom, and its value-added product is nutritious and healthy. Yuen et al. [27] also reported low-fat content in the mushroom *Volvoriella volvacea*. Although the fat content in the juice is non-significantly higher than in the mushroom mg/g dry wt.

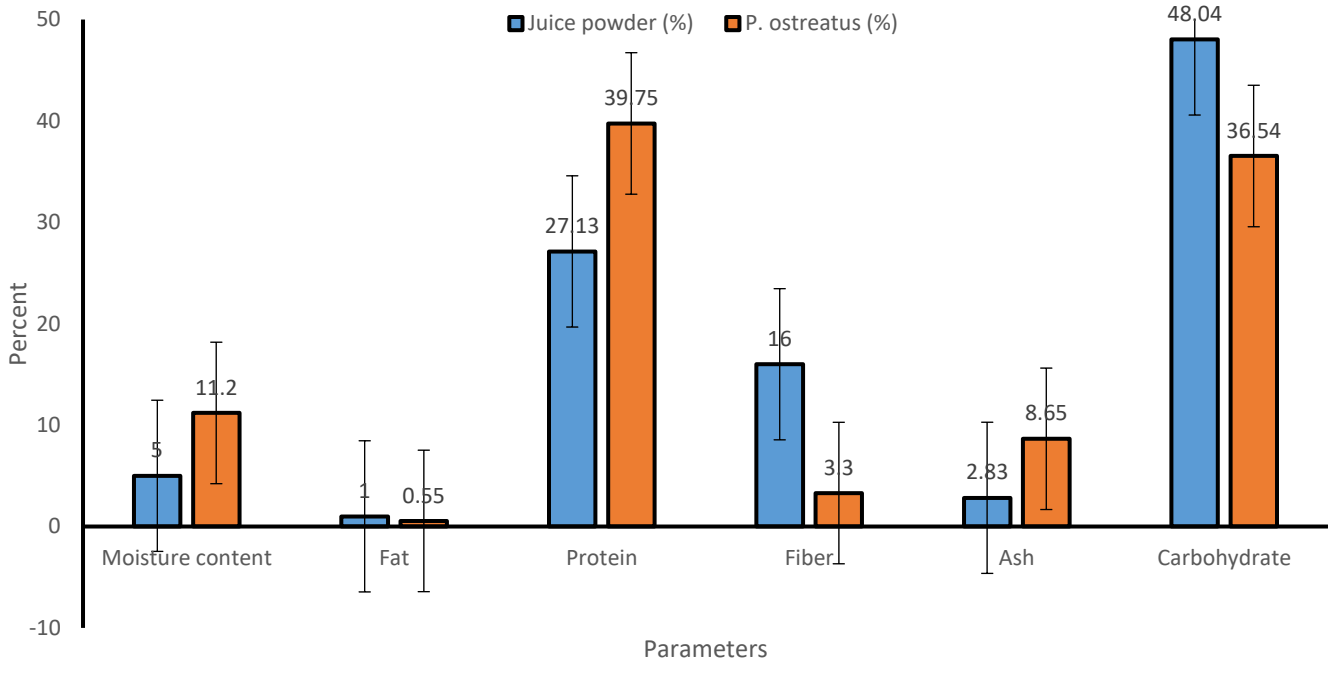


Figure 4: Proximate composition of *Pleurotus ostreatus* and juice powder made with *Pleurotus ostreatus*

Protein content was non-significantly lower in the juice powder (27.13%) while the fiber in the juice (16%) was significantly $p<0.05$ higher compared to the dried mushroom (39.75% and 3.3%), respectively. Consequently, the mineral elements analyzed in this mushroom and its value-added juice powder was relatively comparable with reported literature values. The range of reported literature values (mg/100 g dry weight basis) in mushroom for calcium, magnesium, iron, zinc, copper, manganese were 1.8–59.0[29], 60–250**[**30**]**, 1.46–83.5**[**31**]**, 2.98–15 [32], 7.1–9.5 [31] and 1.81–10.3 [33] mg/100 g dry wt., respectively.

CONCLUSION:

Commercialization of edible fungi and its products has been a major challenge in Nigeria. Although *P. oestratus* has been known to contain several health and nutritional benefits, production and storage are still a major challenge in Nigeria.

The present results provide evidence that processing *P. ostreatus* to powdered juice does not diminish its food value but rather adds value to it. Therefore, the present mineral values increase the safe consumption of mushrooms as supplementary foods to the poor populations preponderantly dependent on cereal diet, as well as project the juice powder as a likely nutritional product.

Authors' contributions: Ofodile, L.N. designed, supervised the experiment and prepared the manuscript, Nicholas-Okpara, Viola A.N. designed the experiment; Saanu Anjorin conducted the heavy metal analysis, Ezenwa, P.C. and Osorinde, R.T. performed the laboratory study; Ikegwu Emmanual M. analyzed the data; Ani, E. prepared and revised the manuscript.

Competing interests: The authors declare that there are no competing interests and no funding was received for this research.

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