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Original Research Article

Effect of Developmental Stages on the Proximate and Mineral Composition of *Pleurotus sajor-caju*

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Abstract

This study was carried out to examine the proximate and mineral contents of an edible mushroom, *P.sajor-caju* in Ekiti State, Nigeria at different stages of development. The mushroom was cultivated on sterilized wood shavings and the fruit bodies were harvested at four stages corresponding to 7, 21, 35 and 49 days after fruiting. The proximate and mineral contents of the mushroom were determined using standard methods. After forty nine days of fruiting, the contents (%) of moisture and crude fiber increased from 90.47 to 94.00 and 0.06 to 0.21 respectively while the contents of protein, fat, ash, carbohydrate and energy (kcal/100g) reduced from 1.21to 0.74, 0.1 to 0.08, 1.07 to 0.69, 7.09 to 5.97 and 32.33 to 25.71 respectively. The mushroom exhibited different variation patterns in their mineral contents with advancing age. The contents (mg/100g) of Mg, Fe and Cu decreased with age while that of K, P, Ca and Zn increased with age. Age had no effect on the content of Mn. This suggests that the recommended harvesting stages would be determined by the particular mineral deficiency being addressed. However, results of the proximate analysis suggest that the mushroom should be harvested early in order not to compromise the nutritional quality.
Keywords: developmental stages, proximate content, mineral content, mushroom, Ekiti State.

INTRODUCTION

For quite a long time, mushrooms have been part of some people's diet and cultures in Nigeria. The level of mushroom knowledge and usage among the Yoruba people of Nigeria has been reported [1, 2]. The traditional usage of mushrooms among the Igbo people of Nigeria has also been reported [3]. Wild mushrooms have long been appreciated for their content of proteins and fiber [4], aroma and flavour, minerals, vitamins and other biologically active substances [5]. The chemical composition and energy values of wild edible mushrooms indicate that they provide key nutrients such as protein and carbohydrates [5]. They can also be used in low-caloric diets for their low contents of fat and energy. Besides, they are also good sources of useful amino acids and contain bioactive compounds. Most authors reported the digestibility of mushroom protein to be as high as 72 to 83% [6, 7]. The digestibility of *Pleurotus* mushrooms is found to be comparable with plant proteins (90%) whereas that of meat is 99% [8]. Mushrooms are also characterized by a high level of well assimilated mineral constituents [9]. Major mineral constituents in mushrooms are potassium, phosphorus, sodium and calcium while copper, zinc and iron form part of minor constituents [10]. The protein value of mushrooms is twice that of asparagus and potatoes, four times that of tomatoes and carrots and six times that of oranges [11]. It was suggested that the food value of mushrooms lies between meat and vegetables [12]. It has also been reported that mushrooms are highly nutritional and compare favourably with meat, egg and milk [13]. Many health promoting substances e.g. antimicrobial, anticancer, antioxidant, cholesterol lowering property and immunostimulatory effects have been documented for some species of mushrooms [14].

Mushrooms are usually harvested at various stages of development. Maturity stage at harvest is among the most important factors that influence the nutritional quality of fruits and vegetables [15]. Despite the potentials of *P. sajor-caju* as a source of nutrients and minerals, little is known about the influence of stages of development on the nutritional quality of the mushroom.

This study was designed to assess the effect of developmental stages on the proximate and mineral composition of the mushroom.

MATERIALS AND METHODS

Preparation of Spawn bottles

Spawn was prepared in polythene packets (200 x 300mm size) and sterilized in an autoclave at 121^{0}C for 30 min. After sterilization, the bags were inoculated with actively growing mycelium of *P. sajor-caju* from PDA slants and incubated at 27±2^{0}C for mycelial growth without any light for 14 days until the mycelium fully covered the grains. These spawn bottles were used for the seeding of mushroom bed.

Bed Preparation

The polypropylene bag method was chosen for mushroom cultivation. Fresh wood shavings were chopped into small pieces of about 2-3 inches in length and soaked in water for 11 hrs. Water was afterwards drained off from the wood shavings. Afterwards, the wood shavings was sterilized using autoclave at 15 psi (per square inch) pressure for 15 mins. The sterilized wood shaving was then placed on a wire mesh net to drain off excess water. Polythene bags (30 x 60 cm) were made available and then filled with the treated wood shavings. All the instruments used were properly sterilized with a dilute solution of potassium permanganate and alcohol. A polypropylene bag was sealed at one end and sterilized wood shavings were filled in through the open end for up to 5 cm. A handful of spawn from the bottle was spread towards the surface edges of this layer. Again, a handful of supplement was applied over the spawn spreader in the bed. Over this, some more wood shavings were and slightly spread over it. The mouth of the polypropylene bag was rolled and closed with stapler pins. Holes were made on the polypropylene bag for aeration. After 14 days, the mycelium of *Pleurotus* grew all over the wood shavings. The wood shaving was then placed in a cool, shady room and sprayed with water 3-4 times daily. The fruits bodies of *Pleurotus* which grew out of the wood shavings were harvested at four stages of development (stage 1to 4) corresponding to 7, 21, 35 and 49 days after fruiting.

Identification of Mushroom

Fresh and matured samples of the edible mushroom were collected and identified in the herbarium of the Department of Plant Science and Biotechnology, Ekiti State University, Ado Ekiti, Nigeria by the curator.

Sample Processing

For each stage, five fruiting bodies were randomly selected and harvested, representing five replicates. The fresh mushrooms were rinsed with deionized water and the edible portions were separated from adhering particles. The edible portions were chopped into small pieces, mashed into paste using mortar and pestle and used for the analysis.

Proximate Analysis

Ash, proteins and lipids were determined using official methods [16]. For crude fibres, 2 g of dried powdered sample were digested with 0.25 M sulphuric acid and 0.3 M sodium hydroxide solution. The insoluble residue obtained was washed with hot water and dried in an oven at 100 °C until constant weight. The dried residue was then incinerated, and weighed for the determination of crude fibres content. Carbohydrate was calculated by difference [17]:

- Carbohydrates (dry matter basis): 100 – (% proteins + % lipids + % ash + % fibres)
- The results of ash, fibres, proteins, lipids and carbohydrates contents were expressed on dry matter basis.

Mineral Analysis

Minerals contents were determined by the ICP-MS (inductively coupled argon plasma mass spectrometer) method [18]. The dried powdered samples (5 g) were burned to ashes in a muffle furnace (Pyrolabo, France). The ashes obtained were dissolved in 10 mL of HCl/HNO 3 and transferred into 100 mL flasks and the volume was made up using deionized water. The mineral composition of each sample was determined using an Agilent 7500c argon plasma mass spectrometer. Calibrations were performed using external standards prepared from a 1000 ppm single stock solution made up with 2% nitric acid.

Statistical Analysis

The data obtained were analysed using SPSS version 16 and means were separated by Duncan's Multiple Range Test (DMRT)

RESULTS AND DISCUSSION

The proximate composition of *P. sajor-caju* at different stages of development is presented in Table 1. The contents (%) of moisture and crude fiber increased from 90.47 to 94.00 and 0.06 to 0.21 respectively, seven weeks after fruiting while the contents of protein, fat, ash, carbohydrate and energy (kcal/100g) decreased from 1.21 to 0.74, 0.10 to 0.08, 1.07 to 0.69, 7.09 to 5.97 and 32.33 to 25.71 respectively. Fat contents were not significantly different among stages 2, 3 and 4. Carbohydrate contents were also not significantly different between stages 3 and 4. The highest energy content was observed in stage 2.

The mineral composition (mg/100g) of *P. sajor-caju* as affected by the stages of development is shown in Table 2. The highest content of Na (69.70), Mg (12.50), Fe (9.87) and Cu (0.40) were observed in stage 1 and decreased continuously until the final stage. The contents of Mg were not significantly different between stage 1 and 2 as well as stage 3 and 4. However, the contents of K, P, Ca and Zn increased significantly with maturity. The contents of P at stage 2 and 3 were not significantly different; the contents of Ca at stage 1 and 2 were also not significantly different.

Meanwhile, the stage of development had no effect on the content of Mn.

The results of the present study demonstrated that the effect of developmental stages was significant ($p<0.05$) for the proximate contents of the mushroom. The quality of vegetables can be influenced by various factors such as genotypic differences, preharvest conditions, cultural practices, stage of maturity, harvesting methods and postharvest handling procedures as well as interaction among these factors [19]. The decrease in the protein, ash and carbohydrate contents of the mushroom with age as observed in the present study tends to agree with the previous work on the effect of phonological stage on the nutrient composition, *in vitro* fermentation and gas production kinetics of *Plantago lanceleota* herbage where a decrease in the contents of crude protein, ash and carbohydrate with maturation was reported [20]. In a study to determine the effect of plant maturity on the proximate composition of *Sesamum radiatum* leaves, it was observed that the protein content increased from four weeks after planting till seven weeks after planting [21]. The result of this study does not agree with this. However, the authors further reported a decrease from seven weeks after planting till the final harvesting was done which tends to be in line with the findings of the present study. The authors also reported a decrease in the ash content of the plant leaves from four weeks to six weeks after planting and then subsequent increase till ten weeks after planting. The continuous decrease in the ash content of the mushroom as observed in the present study does not agree with this pattern. An increase in the carbohydrate content of African eggplant from stage I to harvesting stage 2 was reported in a previous work [22]. The result of the present study does not agree with this. Also, the result of the present study is not in consonance with the earlier report where an increase in the carbohydrate content in the fruit of water chestnut variety, 'Haldipada green' with maturity was observed [23]. In the present study, there was no significant difference in the fat content among stages 2, 3 and 4. This tends to be in consonance with an earlier work where it was observed that the stage of maturity had no effect on the fat content of *Sesamum radiatum* leaves [21]. The observed increase in the fibre content of the mushroom in the present study is in line with the previous studies where increase in the fibre content of African eggplant fruits and orange with maturity were reported [22, 24]. The increase in the fibre content with maturity could be due to increased biosynthesis and accumulation over time of fibre components. The decrease in the other proximate contents of the mushroom in this study is in line with the previous assertion that the nutrient quality of plant leaves generally declines with advancing maturity [25].

In the present study, the effect of the effect of the developmental stages was also significant for all the minerals in the mushroom except Mn. The mushroom exhibited different variation patterns in their mineral contents with advancing age. Minerals such as Na, Mg, Fe and Cu decreased with age while others such as K, P, Ca and Zn increased with age. The decrease in the content of Mg and Fe in the present study does not agree with previous work [26]. It has been suggested that Mg may accumulate in plant leaves with age due to the unfixed nature of its ion [27]. The result of the present study does not agree with this. However, the increase in the content of Ca in this study agreed with the findings of the authors. Ca must accumulate with advancing maturity because of its immobile nature [27]. A decrease in the content of Mg, Fe and Cu and an increase in the content of Zn with maturity of African eggplant has earlier been reported [22].The result of this study is in line with this. The observed decrease in some mineral contents with development stages may be due to their low rate of absorption from the substrate [28].

Table-1: Effect of different stages of development on the proximate contents (%) of *P. sajor-caju*

SOD	Age (days)	Moisture	Protein	Fat	Crude fibre	Ash	Carbohydrate	Energy (kcal/100g)
1	7	90.47^{d}	1.21^{a}	0.10^{a}	0.06^{d}	1.07^{a}	7.09^{a}	32.33^{ab}
2	21	91.17^{c}	1.08^{b}	0.08^{b}	0.08^{c}	0.80^{b}	6.80^{b}	33.50^{a}
3	35	92.09^{b}	0.92^{c}	0.08^{b}	0.10^{b}	0.74^{c}	6.09^{c}	27.15^{bc}
4	49	94.00^{a}	0.74^{d}	0.08^{b}	0.21a	0.69^{d}	5.97^{c}	25.71^{c}

SOD: Stage of development

Means with the same letters within columns are not significantly different ($p < 0.05$)

Table-2: Effect of different stages of development on the mineral contents (mg/100g) of *P. sajor-caju*

SOD	Age (days)	Na	K	Mg	P	Ca	Mn	Fe	Zn	Cu
1	7	69.70^{a}	248.15^{d}	12.50^{a}	184.80^{c}	44.14^{c}	1.11	9.87^{a}	4.21^{d}	0.40^{ab}
2	21	64.40^{b}	266.30^{c}	12.52^{a}	191.33^{ab}	44.05^{c}	1.13	9.15^{b}	4.81^{c}	0.41^{a}
3	35	58.50^{c}	280.35^{b}	10.15^{b}	190.73^{b}	45.20^{b}	1.08	8.16^{c}	5.09^{b}	0.39^{b}
4	49	53.80^{d}	289.80^{a}	9.84^{b}	193.02^{a}	45.95^{a}	1.14	7.91^{d}	5.75^{a}	0.34^{c}

SOD: Stage of development

Means with the same letters within columns are not significantly different ($p < 0.05$)

CONCLUSION

The results of the present study confirmed that the stage of development had a significant effect on the proximate and mineral contents of the mushroom. Early harvesting will ensure that the proximate contents except fiber will not be compromised. The mushroom is rich in minerals; hence, it could contribute significantly to reducing mineral deficiency. However, to integrate the mushroom into a food-based strategy to alleviate mineral malnutrition, the recommended harvesting stages would be determined by the particular mineral deficiency being addressed.

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