Research article

Substrate composition effect on the nutritional quality of *Pleurotus ostreatus* (MK751847) fruiting body

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**ABSTRACT**

Underutilized palm oil waste (shaft and bunch) and sawdust supplemented with wheat and rice bran were used to cultivate mushrooms (*Pleurotus ostreatus*). Substrates were compounded following the designed protocol, bagged, and sterilized. Bags were inoculated with actively growing spawn, incubated at 28 ± 2°C, ramified, and growth parameters were observed and recorded. The highest values were obtained in protein content of (19.14%) in the shaft supplemented with wheat bran, fat contents (1.70%) in the bunch alone, ash content of 10.10% and 9.59% in the fermented bunch, and bunch supplemented with wheat bran respectively. Bunch combined with sawdust gave the highest carbohydrate of 6.19%. Fermented bunch gave the highest value of vitamin A (2.21 UI/100g), E (5.71 UI/100g), and D (5.90 UI/100g). In the current study, it was shown that *Pleurotus ostreatus* cultivated on the palm waste substrate supplemented with rice bran and wheat bran produced better dietic quality mushrooms.

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1. Introduction

Cases of malnutrition and shortage of protein have become a serious concern in many developing countries including Nigeria. In addition, the incidence of food insecurity has remained one of the global greatest challenges with the vastly growing world population, especially in underdeveloped countries (Yohannes et al., 2020; Onyeka et al., 2018; Kinge et al., 2016). This necessitates alternative ways of improving food production with a high protein and nutritional content to meet up with increasing population demands. Hence, among several ways, mushroom cultivation and production remain promising alternatives to meet the vast growing global population demand and sufficient supply of protein in combating the incidence of malnutrition.

Mushrooms are very different from plants, animals, and bacteria, mainly classified into the kingdom mycota or fungi. The kingdom lacks the most peculiar features associated with plants. Thus, fungi feed saprophytically, obtaining food by absorbing dissolved organic material on which they live (Onyeka et al., 2018; Hoa et al., 2015; Oei, 2005). Mushrooms are highly treasured due to their rich characteristic flavour, and cogent nutritional properties with copious diverse kinds of dietary supplements. Thus, mushrooms had been seen as a great source of non-starchy carbohydrates, dietary fiber, proteins, amino acids, minerals, vitamins, and protein contents (Yao et al., 2019; Zied et al., 2017), very useful as a substitute for meat in vegetarian diets but low in caloric value (Stanley and Odu, 2012). Moreover, mushrooms had been reported to possess immunostimulatory and anticancer activity coupled with other biological properties such as antidiabetic, antioxidant, and antitumour (Nowacka-Jechalke et al., 2018; Adebayo et al., 2018; Chaiyasut and Sivamaruthi, 2017; Meng et al., 2016; Cheung, 2013; Lemieszek and Rzeski, 2012; Deng et al., 2009).

*Pleurotus* species often referred to as oyster mushrooms, has remained one of the most commonly grown mushroom species. They are edible fungi and are globally cultivated remarkably in South East Asia, India, Europe, and Africa including Nigeria. *P. ostreatus* (oyster mushroom), *Agaricus bisporus* (button mushroom) and *Lentinula edodes* (shiitake mushroom) had been known to be mostly cultivated mushrooms (Yohannes et al., 2020). Due to the shorter time of growth, and simple growth requirements of oyster mushrooms for cultivation compared to other edible mushrooms, a high percentage of the substrates to fruiting bodies increases profitability and low-cost cultivation technology (Baysal et al., 2003). Oyster mushrooms had been established as the second largest commercially produced mushroom globally (Yohannes et al., 2020; Mohamed Imran et al., 2011; Sánchez, 2010; Baysal et al., 2003) after *A. bisporus*.

*Pleurotus ostreatus* (*Basidiomycota*) belongs to the family of *Pleurotaceae* and is mostly native to China but later spread across the world.

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P. ostreatus have compounds with potent pharmacological activities such as readily digestible proteins, vitamins, and mineral salts which portray them as good dietary and medical products. The high level of mineral salts of potassium, phosphorus, calcium, iron, copper, zinc, magnesium, and selenium contents in P. ostreatus mycelium has been reported (Muszyńska et al., 2016; Adedayo et al., 2014). P. ostreatus protein is characterized by a vast content of exogenous amino acids, which are not manufactured by the human system and have to be supplied in abundant amounts with food. Among the exogenous amino acids are leucine, lysine, and phenylalanine (Salata et al., 2018; Papasyridi et al., 2010).

Diverse substrate compositions had been utilized for the cultivation and production of mushrooms. Pleurotus species have been cultivated successfully on a variety of substrates, including wheat straw, soybean straw (Elattar et al., 2019; Akyuz and Yildiz, 2008) Palm oil waste, shaft, bunch, sawdust, cotton waste (Muswati et al., 2021; Onyeka et al., 2018; Sardar et al., 2017; Garuba et al., 2017; Moonmoon et al., 2010), rice straw, corn cobs (Odunmbaku and Adenipekun, 2018), sugarcane bagasse (Aigbodion et al., 2010), Fig tree, Rain Tree, Mahogany tree, Eucalyptus tree (Bhattacharjya et al., 2015), etc. Furthermore, several research reports had documented the utilization of supplements including rice bran, wheat bran, corn cobs, corn waste, wheat straw, banana leaves as the substrate supplement for the cultivation of oyster mushrooms (Muswati et al., 2021; Adedayo et al., 2021; Onyeka et al., 2018; Odunmbaku and Adenipekun, 2018; Garuba et al., 2017; Bhattacharjya et al., 2015).

The incorporation of supplements in the course of mushroom cultivation had been reported to expedite or boost the enhancement of quality of fruiting bodies of the cultivated mushrooms better than when grown on a substrate alone (Adenipekun and Omolaso, 2015). Hence, the study aimed at evaluating the effect of different substrate compositions and inoculation with different species cultured was purchased from a renowned mushroom commercial centre from Osun States (South-West Nigeria). Adebayo et al., 2018; Odunmbaku and Adenipekun, 2018; Garuba et al., 2017; Bhattacharjya et al., 2015).

2. Materials and methods

2.1. Samples collection and production of tissue cultures

Pleurotus species cultured was purchased from a renowned mushroom commercial centre from Osun States (South-West Nigeria). Adebayo et al. (2021) reported details, particulars, and tissue cultures of the collected species.

2.2. Grain spawn preparation

Millets grains were washed four times, 100 g were weighed into each bottle with 45 min boiling, and air-dried. Calcium carbonate (CaCO₃) of sawdust, BRB (50% each of bunch & rice bran), BWB (50% each of bunch & wheat bran), SSD (50% each of shaft & sawdust), SRB (50% each of shaft & rice bran), and SWB (50% each of shaft & wheat bran), and inoculated with (5–10% w/w) grain spawn as reported in Adebayo et al. (2021). The yield produced was harvested and sun-dried for proximate analysis.

2.4. Proximate analysis

The major proximate components such as dry matter, moisture content, ash content, fat content, crude fibre, total carbohydrate, and crude protein were analyzed following the method of the AOAC (2019).

Determination of moisture content was carried out using moisture evaporation techniques (equation i). Moisture content was determined by weighing the initial weight of the crucible (W1), the weight of the crucible + sample before drying (W2), and the final weight of the crucible + sample after drying. The obtained values were imputed into the equation below to calculate the percentage (%) of moisture content. Total solid (Dry matter) (%) = 100 - moisture (%) (AOAC et al., 2019).

Moisture content = \( \frac{W_1 - W_2}{W_1} \times 100 \) (i)

The determination of Ash content was done by using a clean dried and cooled platinum crucible with approximately 20 g of each of the samples weighed into the crucible (equation ii). Samples with crucible was allowed to blast for 6 h inside furnace at 600 °C, then taken out, cooled inside desiccator and weighed again. The following parameters were determined: empty crucible weight (W1), crucible weight + sample before drying (W2), and crucible weight + ash (W3) (AOAC et al., 2019).

Percentage Weight (%) = Ash weight \times 100/original weight of the used sample.

Ash content = \( \frac{(W_2 - W_1) \times 100}{W_3} \) (ii)

The soxhlet extraction technique described by AOAC et al. (2019) was used to determine the lipid or fat content of the samples (equation iii). Fifteen gram (15 g) of samples weighed, put inside a fat-free thimble, this was then placed in Soxhlet extractor with 200 ml of petroleum ether, and Refluxed of petroleum ether was obtained by placing the flask on the heating mantle. The cooling was achieved with running water over the extractor, solvent was completely siphoned and evaporated using rotary vacuum evaporator with extracted lipid left behind. The lipid was dried and weighed until constant weight achieved at 60 °C, then cooled in desiccator and weighed. Extracted fat or lipid was calculated by difference.

Kjeldahl method which is based on the determination of the amount of reduced nitrogen present in a compound was used to determine crude protein (equation iv). Samples (20 g) were weighed into a filter paper, also added are Na₂SO₄ (ten tablets) and CuSO₄ (1 g), all were put into a Kjeldahl flask with 20 ml of concentrated H₂SO₄ and digested into colourless solution inside fume cupboard. Further actions such as cooling overnight, receiver with 70 ml of 40% NaOH, screening of methyl red indicator, distillation of ammonia gas into the receiver, and titration in the receiver with 0.01M HCl till solution becomes colourless. Following parameters were obtained for calculation: Volume (ml) of required acid to titrate sample (Vs), Volume (ml) of required acid to titrate blank (Vb), acid normality (N acid) (AOAC et al., 2019).

\[ \text{Kjeldahl method} = \frac{V_b \times N_a c i d \times 100}{W_s} \] (iv)

1%w/w were mixed with dried grains and dispersed in the bottle, sterilized in an autoclave at 121 °C for 15 min. Six plugs (6 mm) of actively growing culture were used to inoculate the sterile grains and incubated at optimum growth temperature (23±2 °C).

2.3. Collection, preparation, formulation protocol, and inoculation of the substrates

Palm oil substrate (bunch and shaft) materials were collected, formulated, bagged, and sterilized. Different substrate combinations were formulated as follows: SDT (100% sawdust), BUH (100% bunch), SHT (100% shaft), FBH (100% fermented bunch), BSD (50% each of bunch & sawdust), BBG (50% each of bunch & rice bran), BWB (50% each of bunch & wheat bran), SSD (50% each of shaft & sawdust), SRB (50% each of shaft & rice bran), and SWB (50% each of shaft & wheat bran), and inoculated with (5–10% w/w) grain spawn as reported in Adebayo et al. (2021). The yield produced was harvested and sun-dried for proximate analysis.

Ether extracts (100g) dry matter = (extracted lipids weight / dry sample weight) x100

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The percentage of protein obtained = \( \frac{V_s - V_b \times 0.01401 \times N \text{acid}(6.25)}{100} \) wt of sample used

Determination of crude fibre was done by taking 20 g of the samples and defatted with diethyl ether for 8 h, boiled under reflux with 200 mL of 1.25% \( \text{H}_2\text{SO}_4 \) for 30 min (equation v). The solution was filtered, and washed for acid removal with boiled water. For 30 min, the residue was boiled with 200 mL of 1.25% sodium hydroxide (NaOH), and weighed couch crucible was used for filtration. Crucible was dried with samples in an oven at 100 °C, allowed to cool in a desiccator, and the weight was taken later. The solution was incinerated at 600 °C in a muffle furnace for 2–3 h, allowed to cool in a desiccator and weighed (AOAC et al., 2019).

Fibre weight = \( (C_2 - C_3) \times \frac{100}{\text{wt of original sample}} \)

Carbohydrate content (%) = 100 - [Protein (%) + Moisture (%) + Ash (%) + Fibre (%) + Fat (%)]. Energy or Caloric Value (KJ/100g) = \( \{[\text{Protein} \times 16.7] + [\text{Lipids} \times 37.7] + [\text{Carbohydrate} \times 16.7]\} \) (AOAC et al., 2019).

2.5. Mineral element analysis

Determination of mineral contents (Zinc, Calcium, Magnesium, Potassium, Iron, and Sodium) were done using the method AOAC et al. (2019). The ash was obtained from samples at 550 °C. Ten (10 ml) of 20% of hydrochloric acid was used to boil in a beaker, filtered and made up with deionized water to the mark. Atomic Absorption Spectrophotometer (AAS Model Bulk Scientific Accuzy 211) was used to determine the minerals compositions from the resulting solution. Values obtained were reported in ppm (mg/100 g). Magnesium, Calcium, and Chlorine were determined spectrophotometrically using UV/V Spectrophotometer model 752N.

2.6. Vitamin A, E, and D determination

Vitamins A, E, and D were determined using high-performance liquid chromatography (HPLC) and Liquid Chromatography-Mass Spectrometry (LC-MS) with UV detection as described Phillips et al. (2011). The samples were prepared and vitamins A and E were detected using HPLC (High-Performance Liquid Chromatography), and the level of vitamin D was measured by LC-MS (Liquid Chromatography-Mass Spectrometry).

2.7. Analysis of data

3. Analysis of the data from the study were reported in Mean ± SEM with ANOVA (One-way). Duncan Multiple Range Test (DMRT) was also carried out for statistical comparisons with version 20 SPSS software at the 5% level of significance.

3. Results and discussion

3.1. Cultivation of mushroom

The schematic illustration in Figure 1 shows the step-by-step procedure involved in mushroom cultivation which consists of the mushroom samples collection and characterization. Mushroom cultivation protocol followed the spawn production using grains, substrate formulation protocols, raw materials for substrate preparation, processing of the raw materials, composting of the raw materials, harvests of the mushroom, nutritional analysis which consist of the proximate analysis, minerals, and vitamins. The simple, seamless, and effective mushroom protocol was adopted in this study and this method has proved to be

![Figure 1. Step-by-step procedure involved in mushroom.](image-url)
away out from laborious, and time-consuming with lesser yields than some available mushroom cultivation methods.

3.2. Substrate composition effect on the proximate value of Pleurotus ostreatus

The nutritional composition of the Pleurotus ostreatus obtained from different substrates used in this study is shown in Table 1. Substrates variation affects the percentage of crude protein in oyster mushrooms. The protein content obtained in this study ranged from 10.09 to 19.14%. The highest crude protein (19.14%) was obtained in shaft supplemented with wheat bran (SWB) while sawdust alone (SDT) gave the least value of 10.09%. The protein content obtained in this study ranged from 10.09 to 19.14%.

Each value is a mean of 3 replicates. Values in the same column with different letters as superscripts are significantly different by Duncan’s multiple range test (P < 0.05). SDT - Sawdust; FBH - Fermented Bunch; BUH - Bunch; BSD - Bunch + Sawdust; BWB - Bunch + Wheat Bran; BRB - Bunch + Rice Bran; SHT - Shaft; SSD - Shaft + Sawdust; SWB - Shaft + Wheat Bran; SRB - Shaft + Rice Bran.

### Table 1. Effect of substrates on the proximate composition (%/weight) of the harvested P. ostreatus.

| SUBSTRATE | Crude Protein | CHO | Calorific Value KJ/100g | Moisture | Ash | Crude Lipids | Crude Fibre |
|-----------|---------------|-----|--------------------------|----------|-----|-------------|-------------|
| BRB       | 16.98 ± 0.39" | 3.44 ± 0.75" | 2.97 ± 1.45" | 8.57 ± 1.17" | 8.61 ± 0.26" | 1.30 ± 0.14" | 11.11 ± 0.37" |
| SRB       | 16.62 ± 0.41" | 5.31 ± 0.43" | 2.63 ± 1.77" | 5.98 ± 0.79" | 9.56 ± 0.49" | 1.36 ± 0.28" | 11.18 ± 0.01" |
| BUH       | 17.78 ± 0.47" | 4.63 ± 0.69" | 3.44 ± 0.69" | 8.84 ± 0.06" | 6.45 ± 0.32" | 1.70 ± 0.29" | 10.61 ± 0.09" |
| BWB       | 18.20 ± 0.15" | 2.11 ± 0.42" | 3.58 ± 1.80" | 7.51 ± 0.97" | 9.59 ± 0.11" | 1.58 ± 0.29" | 11.01 ± 0.01" |
| FBH       | 17.98 ± 0.09" | 2.87 ± 0.07" | 4.79 ± 6.18" | 7.06 ± 0.12" | 10.10 ± 0.03" | 1.50 ± 0.18" | 10.50 ± 0.07" |
| SHT       | 15.98 ± 0.08" | 5.77 ± 0.38" | 2.77 ± 11.34" | 6.56 ± 0.46" | 7.00 ± 0.01" | 1.67 ± 0.24" | 10.02 ± 0.51" |
| SSD       | 17.13 ± 0.05" | 5.12 ± 0.05" | 5.76 ± 9.83" | 7.33 ± 0.18" | 8.30 ± 0.28" | 1.61 ± 0.35" | 10.52 ± 0.15" |
| BSD       | 16.62 ± 0.07" | 6.19 ± 2.50" | 5.54 ± 37.09" | 6.73 ± 1.54" | 4.12 ± 0.59" | 1.44 ± 1.13" | 9.89 ± 0.57" |

Each value is a mean of 3 replicates. Values in the same column with different letters as superscripts are significantly different by Duncan’s multiple range test (P < 0.05). SDT - Sawdust; FBH - Fermented Bunch; BUH - Bunch; BSD - Bunch + Sawdust; BWB - Bunch + Wheat Bran; BRB - Bunch + Rice Bran; SHT - Shaft; SSD - Shaft + Sawdust; SWB - Shaft + Wheat Bran; SRB - Shaft + Rice Bran.

The carbohydrate content obtained in this study indicates that mushrooms are good energy food sources which agrees with the reports by Adedayo et al. (2014) with carbohydrate values ranging from 5.89 to 9.67%. However, the carbohydrates obtained in this study are lower than the ones reported by Odunmbaku and Adenipekun (2018), which ranges between 14.24-17.11% when grown on cotton waste and sawdust. The bioconversion of carbohydrates in the colonized wastes into mycelia protein could explain the decrease in carbohydrates seen with the addition of a specific proportion of additives (Iyayi, 2004). The Ash content obtained in this study (4.12–10.10%) is greater than the values presented by Onyeka et al. (2018) and Zahid et al. (2010). The substrate composition is one of the principal factors influencing the nutritional formulation of mushrooms in the mushroom cultivation process.

### Table 2. Effect of substrates on the mineral composition of the harvested P. ostreatus.

| SUBSTRATE | Fe ppm | K ppm | Zn ppm | Ca ppm | Mg ppm | Na ppm |
|-----------|--------|-------|--------|--------|--------|--------|
| BRB       | 2.25 ± 0.00 ab | 7.82 ± 0.00 ab | 2.86 ± 0.00 ab | 4.85 ± 0.00 ab | 4.39 ± 0.00 ab | 0.15 ± 0.00 ab |
| SRB       | 1.88 ± 0.00 ab | 7.42 ± 0.00 ab | 2.92 ± 0.00 ab | 3.06 ± 0.00 ab | 4.46 ± 0.00 ab | 0.16 ± 0.00 ab |
| BUH       | 2.39 ± 0.00 ab | 8.78 ± 0.00 ab | 2.91 ± 0.00 ab | 3.92 ± 0.00 ab | 0.15 ± 0.00 ab | 0.00 ± 0.00 ab |
| BWB       | 2.65 ± 0.00 ab | 6.64 ± 0.00 ab | 2.84 ± 0.00 ab | 3.39 ± 0.00 ab | 4.60 ± 0.00 ab | 0.16 ± 0.00 ab |
| FBH       | 1.71 ± 0.00 ab | 7.63 ± 0.00 ab | 2.92 ± 0.00 ab | 5.07 ± 0.00 ab | 2.65 ± 0.00 ab | 0.09 ± 0.00 ab |
| SHT       | 2.29 ± 0.00 ab | 8.55 ± 0.00 ab | 2.93 ± 0.00 ab | 3.68 ± 0.00 ab | 4.26 ± 0.00 ab | 0.15 ± 0.00 ab |
| SSD       | 1.95 ± 0.00 ab | 6.69 ± 0.00 ab | 2.90 ± 0.00 ab | 5.10 ± 0.00 ab | 2.90 ± 0.00 ab | 0.10 ± 0.00 ab |
| BSD       | 1.84 ± 0.00 ab | 7.06 ± 0.00 ab | 2.92 ± 0.00 ab | 5.87 ± 0.00 ab | 4.27 ± 0.00 ab | 0.15 ± 0.00 ab |

Each value is a mean of 3 replicates. Values in the same column with different letters as superscripts are significantly different by Duncan’s multiple range test (P < 0.05). SDT - Sawdust; FBH - Fermented Bunch; BUH - Bunch; BSD - Bunch + Sawdust; BWB - Bunch + Wheat Bran; BRB - Bunch + Rice Bran; SHT - Shaft; SSD - Shaft + Sawdust; SWB - Shaft + Wheat Bran; SRB - Shaft + Rice Bran.
compositions of mushrooms (Odunmibaku and Adenipekun, 2018). The grown species have an impact on the nutritional characteristics of mushrooms. The better performance obtained in using Rice bran and Wheat bran as an additive could be due to their high riches/content in nutritional value. They had been known to contain a large variety of biologically active substances (Narayan et al., 2006; Onipe et al., 2015) along with robust protein, minerals, vitamins, fatty acids, and dietary fibers (Prueckler et al., 2014; Onipe et al., 2015).

3.3. Substrate composition effect on the mineral contents of Pleurotus ostreatus

The mineral element composition of the Pleurotus ostreatus harvested from all the substrates formulations is shown in Table 2. In this study, the highest Iron (5.01 ppm) contents were obtained from the oyster mushroom cultivated on BSD while the mushroom harvested from SSD gave the lowest value of 1.64 ppm. Pleurotus ostreatus harvested from BUH (8.78 ppm) gave the highest Potassium content, followed by BWB (8.64 ppm) and SHT (8.55 ppm), while the least amount of 6.69 ppm was obtained from the Pleurotus ostreatus grown on SWB. The Zinc content of the mushroom harvested from all the Ten formulated substrates used in the study was not significantly different.

The Zinc content ranges from 2.69 to 2.93 ppm. Mushrooms cultivated on SHT (8.57 ppm) gave the highest Calcium content, followed by SWB (5.10 ppm), SSD (5.09 ppm), FBH (5.07 ppm), and BSD (5.06 ppm), while SRB recorded the least Calcium content of 5.87 ppm. The presence of calcium in mushrooms makes it an important food for bone formation and maintenance in the body and also for the normal functioning of nerves and muscles in humans and other animals. The calcium content of the oyster mushroom obtained in this study is lower than the value reported by Afikwau et al. (2013) but agrees with the amount of calcium in oyster mushrooms reported by Zahid et al. (2010).

Sodium and potassium are of great importance in maintaining an osmotic balance between cells and the intestinal fluid in animal systems. The amount of sodium and potassium present in the Pleurotus ostreatus showed that oyster mushrooms would be good at lowering blood pressure, reducing the risk of osteoporosis, and also maintaining bone health (Wani et al., 2010). It is a great diet for those suffering from hypertension and heart disease due to the high potassium-to-sodium ratio (Purkayastha and Nayak, 1981). The amount of potassium in this study found in the harvested Pleurotus ostreatus (8.78) is lower than 35.17 and 122.28 reported by Zahid et al. (2010) and Afikwau et al. (2013) respectively.

Pleurotus ostreatus (PO) contains iron, which is essential for the formation of the oxygen-carrying pigment in red blood cells (haemoglobin) and the cytochrome that aids in cellular respiration. The amount of iron found in this study ranged from 1.64 to 5.01% which is within the range of value (1.15) reported by Afikwau et al. (2013).

Magnesium and Calcium content in this study is in line with the result documented by Onyeka et al. (2018) who examine the effect of substrate media on the growth, yield, and nutritional composition of domestically grown oyster mushroom (Pleurotus ostreatus). However, higher Potassium, Iron, and Zinc with lower Sodium content were observed in this study compared to Onyeka et al. (2018). This study showed higher nutritional content than that documented by Odumakhu and Adenipekun (2018) but lower when compared to the study by Hoss et al. (2018).

The differences in the chemical and biological composition of the substrate utilized in this study could be responsible for the differences obtained in the mineral content of oyster mushrooms in this study (Muswati et al., 2021; Onyeka et al., 2018; Ahmed et al., 2009). For example, the highest values of crude protein were obtained in the substrates augmented with wheat bran (BWB and SWB). Notably increased values of crude protein compared with other substrates suggest that the higher level of protein in wheat bran might affect the value of crude protein in the mushroom yield (Muswati et al., 2021). The same reason may be responsible for the reduction in the level of Calorific value and carbohydrate value of the mushroom. On the other hand, the high level of Calorific value in SSD, BSD, and FBH may be unconnected with the high rate of fermentation that took place in the substrates due to combinations of substrate materials (SSD and BSD) and procedure used (FBH) compared to others. The mushrooms get their food from the substrate on which they grow, which explains the observed differences in the mineral composition of the mushrooms grown on various substrates (Muswati et al., 2021; Oei, 2003; Tripathi, 2005; Ahmed et al., 2009).

The mineral composition in the human diet plays a major role in the formation of cells and tissue in human development (Koyyalamidi et al., 2013). The major essential mineral elements such as Sodium, Magnesium, Potassium, Calcium, Iron, and Zinc help to regulate the osmotic regulation of fluids and oxygen transport in the human body (Murillo and Suarez, 2020). Zinc, Sodium, and Iron are found in small amounts in this current study, while other mineral components were found in a considerable amount in Pleurotus ostreatus. The kind of substrate formulation and composition utilized in the cultivation of the mushroom significantly might affect and determine the mineral content of the harvested mushroom. The essential elements such as potassium had been documented to play a vital role in the synthesis of amino acids and proteins while copper in association with manganese, takes part in the enzymatic catalyzes which are major in all biological and physiological processes in living organisms. Potassium is important in the synthesis of amino acids and proteins, and copper in conjunction with manganese, plays an important role in enzymatic catalyzes, which are essential in all biological and physiological processes in living organisms (Murillo and Suarez, 2020; Onyeka and Okwujiako, 2020; Idowu and Kadiri, 2013; Saiqa et al., 2008). However, the result from this study revealed that the harvested mushrooms cultivated on the different utilized substrates in this study could be a good source of many dietary minerals.

3.4. Effect of substrate composition on the vitamin components of oyster mushroom

The contents of vitamin A, E, and D of cultivated oyster mushroom, ranges from 0.23-2.21 mg/100g, 2.84-5.71 mg/100g, and 4.00-5.90 mg/100 g respectively (Table 3). It was observed that the mushroom cultivated on the FBH had the highest Vitamin A, E, and D which indicate the richness of FBH in Vitamin than any other substrate used in this study. The highest production of Vitamins in FBH could be a result of the fermentation process which may likely be contributed by the organisms that took part in fermentation. Variations in oyster mushroom vitamin content are most likely due to differences in substrate makeup (Vimla and Sundeh, 2005).

Table 3. Vitamins Composition of mushrooms obtained from the different substrate.

| SUBSTRATE | VITAMIN A IU/100g | VITAMIN E Mg/dl | VITAMIN D IU/100g |
|-----------|-----------------|-----------------|-----------------|
| BBM       | 0.23 ± 2.26     | 3.13 ± 1.40     | 4.55 ± 0.03     |
| SRB       | 2.10 ± 0.85     | 4.17 ± 0.80     | 5.40 ± 0.02     |
| BUH       | 1.65 ± 0.64     | 5.35 ± 0.70     | 4.10 ± 0.03     |
| BWB       | 1.80 ± 0.54     | 5.42 ± 0.50     | 4.60 ± 0.03     |
| FBH       | 2.21 ± 2.22     | 5.71 ± 0.40     | 5.90 ± 0.19     |
| SHT       | 2.01 ± 2.34     | 4.82 ± 0.10     | 4.00 ± 0.29     |
| SWB       | 1.75 ± 1.15     | 4.47 ± 0.55     | 5.05 ± 0.07     |
| SSD       | 1.71 ± 1.96     | 2.84 ± 0.10     | 5.50 ± 0.00     |
| BSD       | 2.14 ± 0.06     | 5.62 ± 0.15     | 4.35 ± 0.03     |

Each value is a mean of 3 replicates. Values in the same column with different letters as superscripts are significantly different by Duncan's multiple range test (P < 0.05). SDT - Sawdust; FBH - Fermented Bunch; BUH - Bunch; BSD - Bunch + Sawdust; BWB - Bunch + Wheat Brain; BBM - Bunch + Rice Brain; SHT - Shaft; SSD - Shaft + Sawdust; SWB - Shaft + Wheat Bran; SRB - Shaft + Rice Bran.
Generally, it can be deduced from this study that supplemented substrates produced or give rise to mushrooms with better nutritional value than the non-supplemented substrate. Substrate supplemented with wheat bran and rice bran actively supported mushroom quality in terms of nutritional and medicinal values compared to the single substrate (e.g. Sawdust) utilized.

4. Conclusion
This research shows that palm oil bunch, palm oil shaft supplemented with wheat bran, and rice bran are ideal substrates for growing P. ostreatus, and that varied combinations had a substantial impact on the nutritional composition of the grown oyster mushroom. The findings showed that the substrate could be modified to produce the desired mushroom nutrient profile. Substrate supplemented with wheat bran and rice bran gave the best proximate composition and nutritional content of P. ostreatus in addition to having the highest crude protein concentration, while FBH substrate gave the highest vitamins. Wheat bran and Rice bran could consequently be recommended as suitable additions for enhancing value-added P. ostreatus growth, especially in terms of nutrition.

Most agricultural waste can be diverted into mushroom production by the government, scientists, nutritionists, and the food supply stakeholders. This will add to the economic gain, protect the environment and at the same time be a high source of nutritional food for the nation.

Declarations

Author contribution statement
Elkanah, F.A; Oke, M.A: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Adebayo, E.A: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools, or data; Wrote the paper.

Adebowo, E.A.; Adegbuyi, O.A.; Arowolo, A.O.; Adeyinka, J.O.: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement
Data will be made available on request.

Declaration of interests statement
The authors declare no conflict of interest.

Additional information
No additional information is available for this paper.

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