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Effect of zinc fortification on the vitamin, mineral, and amino acid composition of *Pleurotus ostreatus* cultivated on different wood substrate

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Abstract

Zinc is an essential nutrient and appears to be deficient in the diet of most individuals, in both industrialized and non-industrialized countries. Hence, strategies to increase the zinc content of food are germane. This study examines the impact of zinc fortification on the vitamin, mineral, and amino acid composition of *Pleurotus ostreatus* cultivated on different tropical wood substrates, namely *Canarium* sp., *Pycnanthus angolensis*, and *Ceiba pentandra*. Results showed significant variations in the nutritional composition of both zinc-fortified and non-fortified *P. ostreatus*. Non-zinc fortified *P. ostreatus* cultivated on *Pycnanthus angolensis* has the highest vitamin A content (8.08 mg/100 g), whereas zinc-fortified samples grown on the same substrate recorded the highest vitamin C concentration (282.72 mg/100 g). Mineral analysis revealed a general increase in zinc content in *P. ostreatus* across all fortified substrates, with values ranging from 0.51 to 1.95 mg/100 g. The highest zinc accumulation was observed in *P. ostreatus* grown on zinc-fortified *Pycnanthus angolensis*. Potassium levels were naturally higher in non-fortified samples but increased slightly in fortified mushrooms cultivated on *Canarium* and *Pycnanthus* substrates, from 714.03 to 717.50 mg/100 g and from 539.96 to 580.33 mg/100 g, respectively. Amino acid profiling showed glutamic acid as the most abundant amino acid, with values between 9.07 and 11.17 g/100 g. The highest level was found in zinc-fortified *P. ostreatus* cultivated on *Pycnanthus angolensis*. The study shows that zinc fortification, in synergy with specific wood substrates, enhances the nutritional value of *P. ostreatus*, making it a promising functional food in addressing micronutrient deficiencies.

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Introduction

Oyster mushrooms (*Pleurotus* spp) are widely consumed for their attractive taste, aroma with nutritional and medicinal values[1]. *Pleurotus ostreatus*, a common oyster mushroom, is a common edible species. Mushrooms, with their aroma, texture, nutritional value and high productivity per unit area, have been identified as an excellent food source to alleviate malnutrition in developing countries[2]. One of the reasons for mushrooms being widely accepted is their nutritive content. Mushrooms are eaten as a meat substitute and flavouring. In general, edible mushrooms are low in fat and calories, rich in vitamins B and C, contain more protein than any other vegetable food, and are also a good source of mineral nutrients[3]. In addition, mushrooms rich in dietary fiber have been shown to act as antitumor, antifungal, and antiviral agents and reduce hypercholesterolemia activity[4].

Zinc is an essential nutrient and seems to be deficient in the diet of many people, in both industrialized and non-industrialized countries[5]. Low zinc levels in children have been linked to stunted growth, poor appetite, and poor taste[6]. Zinc is present in small amounts in foods. While the body doesn't need a large amount of zinc, it is still possible for a person to become zinc-deficient. Since the body doesn't store zinc, it's important to obtain enough of this mineral from food to prevent a deficiency. Zinc is a trace element that is essential for a healthy immune system. A lack of zinc can increase susceptibility to disease and illness[7]. Zinc is essential for immune function, DNA synthesis, and wound healing, while iron is critical for oxygen transport and energy production[8]. The fortification of mushroom substrates with trace elements like zinc and iron can improve the nutritional profile of *P. ostreatus*, as these elements are integral to various health functions[9]. Studies indicate that mushrooms grown on zinc- and iron-enriched substrates exhibit enhanced antioxidant capacity and mineral content[10,11]. Additionally, mineral fortification may improve the stability of bioactive compounds such as ergosterol and polysaccharides in the mushrooms, further enhancing their therapeutic potential[9].

Tropical wood substrates fortified with zinc provide a unique advantage for enhancing the nutraceutical profile of *P. ostreatus*. For example, Adebayo[10] observed that fortification with zinc on tropical substrates like *Pycnanthus angolensis* led to a higher mineral uptake by mushrooms, translating into a more significant concentration of these essential nutrients in the edible fruiting bodies. Such fortification strategies are promising, especially for regions with nutritional deficiencies, as they offer a sustainable approach to increase dietary mineral intake[9]. The nutraceutical properties of *Pleurotus ostreatus* are significantly influenced by the type of tropical wood substrate used, and the fortification with essential minerals like zinc[11]. *Canarium* sp., *Ceiba pentandra*, and *Pycnanthus angolensis* provide unique nutrient and structural profiles that support the growth and enhance the bioactivity of *P. ostreatus*[11]. Fortifying these substrates with zinc further elevates the nutritional value of the mushrooms, making them a valuable food source for health promotion and disease prevention[12]. This present study therefore, seeks to assess the vitamin, mineral, and amino acid composition of *P. ostreatus* cultivated on different wood substrates fortified with zinc.

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Materials and methods

Substrate preparation and cultivation of *Pleurotus ostreatus*

Pleurotus ostreatus was cultivated for 12 to 14 weeks on the sawdusts obtained from *Canarium* sp., *Ceiba pentandra*, and *Pycnanthus angolensis*. The dry substrates were checked for consistency and were mixed thoroughly with water. The substrates were moistened with water to prevent dryness. About 800 g of medium was filled into polypropylene bags, and sealed using paper and polyvinyl rings. The substrates in bags were sterilized in the autoclave, and were left to cool down to ambient room temperature[13].

Fortification of *Pleurotus ostreatus* with Zinc chloride

Eight millimeters of zinc chloride, at a concentration of 50 mg/kg, was also injected into the bags containing substrates. A control treatment with no zinc chloride was also prepared. Following this, substrates in separate bags were inoculated with 30 g of spawn. The bags were kept in the dark with relative humidity of 75% to ramify[13]. The growth of mycelium in each bag was observed. Once the mycelium fully covered the substrate, the bags were left open in the growing house to allow fruit body formation. The mushroom fruit bodies were harvested, air-dried, and then ground into powder using a grinding machine (Lexmark Mixer Grinder KP- 4055).

Determination of vitamin A and C content of cultivated *Pleurotus ostreatus*

Vitamin A and C content was determined according to the method of Ötles & Ozgoz[14]. The mushroom samples were collected and thoroughly cleaned of debris and other adhering matters. They were freeze-dried to preserve vitamin content. The freeze-dried mushrooms were ground into a fine powder, and stored in airtight containers at −20 °C until analysis.

For the extraction of vitamin A, one gram of powdered sample was weighed and added to 25 mL of ethanol, and homogenized for 2 min. Twenty five mL of hexane was added and shaken for 5 min. The upper hexane layer was collected in separate phases, and the hexane was evaporated under reduced pressure, and the residue was reconstituted in methanol[15]. Vitamin C was extracted by weighing **o**ne gram of powdered sample and adding to it 50 mL of 0.1 M HCl, and then homogenized for 2 min. Twenty five mL of hexane was added and shaken for 5 min. It was heated in a water bath at 95°C for 30 min, and centrifuged at 5,000 rpm for 10 min, and the supernatant was collected[15].

Standard solutions for vitamins A and C were prepared. The extracts were injected into High-Performance Liquid Chromatography (HPLC) system with a UV/Vis detector at 265 nm for vitamin A and 254 nm for vitamin C. Retention times and peak areas were compared with standards to determine concentrations[16]. LC-MS was used for precise quantification and confirmation. Mass Spectrometry **(**MS) parameters were optimized for each vitamin[17]. Quality control was performed with standard solutions and blanks. Methods for linearity, accuracy, precision, and sensitivity were validated. Triplicate analyses for reproducibility were **c**onducted. Vitamin content was calculated using calibration curves from standards and the results expressed as mg or μg per 100 g of dry mushroom weight.

Determination of mineral content of cultivated *P. ostreatus*

Mineral content of cultivated *P. ostreatus* was determined by the wet-ashing method, followed by mineral level analysis[18]. Triplicate samples of 1 g each of *P. ostreatus* were weighed into porcelain crucibles, and placed in a muffle furnace. The temperature was gradually raised to 450 °C, and the samples were ashed at this temperature for 5–6 h. After cooling to room temperature, the ash was dissolved in 1 ml of 0.5% HNO_3. The sample volume was brought to 100 ml, and the mineral levels were analyzed using an Atomic Absorption Spectrophotometer Buck 201 VGP. The mineral content was calculated using the formula:

$$Mineral(mg/100g) = \frac{R \times V \times D}{Wt}$$

When R = solution concentrate obtained from the graph, V = volume of sample digest, D = dilution factor, and Wt = weight of sample.

Total amino acid analysis of cultivated mushrooms

The mushroom sample (1–3 g) was hydrolyzed under nitrogen gas with 10 ml of 4 N NaOH and 200 μg of ascorbic acid as an antioxidant in an autoclave at 110 °C for 16 h and adjusted to pH 9.00. The hydrolysate was then filtered through a 0.45 μm cellulose acetate membrane filter before being injected into the HPLC for analysis. The amino acid composition was determined using reversed-phase HPLC and gradient elution, following the method outlined by Henderson et al.[19]. The analysis was performed using the Agilent 1100 HPLC system (Agilent Technologies) with an autosampler, a Zorbax-Eclipse XDB-C18 column (4.6 × 150 mm, 5 μm) with a Zorbax Eclipse -AAA guard column (4.6 × 15.5 mm), and a fluorescence detector. Chemstation Rev.A.09.03 (1417) (Agilent Technologies 1990–2002) was used for data acquisition and analysis. The sample was subjected to automatic pre-column derivatization with a combination of OPA-3MPA for primary amino acids and FMOC for secondary amino acids. Mobile phase A contains 40 mmol/l Na_2HPO_4 at pH 7.8, and B contained 45% acetonitrile, 45% methanol, and 10% deionized water. The temperature of the chromatographic column was set at 40°C with a flow rate of 2 mL/min. The detector was set to 340/450 (Ex/Em) at 0 min and 266/305 (Ex/Em) at 15 min.

Calculation of amino acid values from the chromagram peaks

The net height of each peak produced by the Technicon Sequential Multisample (TSM) chart recorder (each representing one amino acid) was measured. The half-height of the peak on the chart was found, and the width of the peak at half height was accurately measured and recorded. The approximate area of each peak was calculated by multiplying the height by the width at half height.

The norleucine equivalent (NE) for each amino acid in the standard mixture was calculated using the formula:

$$NE = \frac{Area\ of\ norcleucin}{Area\ of\ each\ amino\ acid}$$

A constant (S) was calculated for each amino acid in the standard mixture: Sstd = NEstd × mol. Weight × MAAstd Amino Acid (g/100 g protein) = NH × W (a) NH/2 × Sstd × C.
where:

$$C = \frac{Dilution \times 16}{Sample\ Wt(g) \times N\% \times Vol.loaded} \div NH \times W(Nlew)$$

where, NH = net height, W = width at half height, Nleu = norcleucine.

Statistical analysis of data

The data obtained were subjected to statistical analysis of variance (ANOVA) and Duncan's Multiple Range Test was used to compare means. The 't' value was tested at 95% confidence interval.

Results

Vitamin A and C content (mg/100 g) of cultivated mineral fortified and non-mineral fortified *P. ostreatus*

Non-zinc fortified *P. ostreatus* cultivated on *Pycnanthus angolensis* has the highest Vitamin A content (8.08 mg/100 g), while zinc-fortified *P. ostreatus* cultivated on the same wood substrate has the highest Vitamin C content (282.72 mg/100 g), as shown in Fig. 1. There were notable variations in the levels of both vitamins across the different samples.

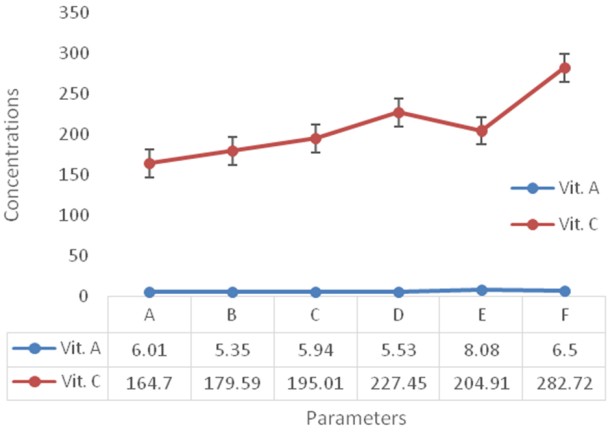

Fig. 1 Vitamin A and C content (mg/100 g) of cultivated mineral fortified, and non-mineral fortified *P. ostreatus*. A, *P. ostreatus* cultivated on wood substrate (*Canarium* sp.) without fortification. B, *P. ostreatus* cultivated on wood substrate (*Canarium* sp.) fortified with zinc. C, *P. ostreatus* cultivated on wood substrate (*Ceiba pentandra*) without fortification, D, *P. ostreatus* cultivated on wood substrate (*Ceiba pentandra*) fortified with zinc. E, *P. ostreatus* cultivated on wood substrate (*Pycnanthus angolensis*) without fortification. F, *P. ostreatus* cultivated on wood substrate (*Pycnanthus angolensis*) fortified with zinc.

Mineral content of the dried cultivated mineral fortified and non-mineral fortified *Pleurotus ostreatus*

Table 1 shows the mineral content of the cultivated oyster mushroom. Zinc (Zn) contents notably increased in mushrooms across all substrates. Potassium (K) was more abundant in the non-fortified *P. ostreatus* and increased in zinc fortified *Canarium* and *Pycnanthus angolensis* substrates from 714.03 to 717.50 mg/100 g, and from 539.96 to 580.33 mg/100 g, respectively. Zn content ranges from 0.51 to 1.95 mg/100 g, with the highest in *P. ostreatus* cultivated on wood substrate (*Pycnanthus angolensis*) fortified with zinc.

Amino acid composition (g/100 g) of cultivated mineral fortified and non-mineral fortified *P. ostreatus*

Table 2 shows the amino acid content of the cultivated *Pleurotus ostreatus*. Glutamic acid was the highest amino acid recorded, and the values range from 9.07 to 11.17 g/100 g, with zinc fortified *P. ostreatus* cultivated on the wood substrate *Pycnanthus angolensis* having the highest value of 11.17 g/100 g.

Discussion

The results obtained from this study revealed that wood substrates and zinc fortification markedly affect vitamin C and A levels in cultivated *P. ostreatus*. It has been reported that zinc deficiency limits the bioavailability of some vitamins[20,21]. Moreover, the levels of these vitamins can be influenced by substrate type and mineral supplementation[22]. Vitamins are essential for human health[23].

The results of the mineral content of the zinc-fortified and non-zinc-fortified *Pleurotus ostreatus* showed significant differences ($p > 0.05$) in the essential macro minerals (Mg, P, K, Ca, Na), and micro minerals (Mn, Fe, Cu, Zn) in the mushroom. The highest Zn concentration was in *P. ostreatus* cultivated on *Pycnanthus angolensis* fortified with zinc (1.95 mg/100 g), while the lowest Zn concentration was in unfortified *P. ostreatus* cultivated on *Canarium* sp. (0.51 mg/100 g). Research by Ariyo et al.[11] reveals that substrate fortification influences Zn content in mushrooms. There was also significant differences ($p > 0.05$) in the Manganese (Mn), Nickel (Ni), Magnesium (Mg), Potassium (K), Sodium (Na), Phosphorus (P) content across the cultivated *P. ostreatus*, with no consistent trend observed. *P. ostreatus* cultivated on *Ceiba pentandra* fortified with zinc has the

Table 1. Mineral composition (mg/100 g) of cultivated mineral fortified and non-mineral fortified *P. ostreatus*.

Minerals	A	B	C	D	E	F
Fe	0.33 ± 0.06^{ab}	0.39 ± 0.05^{b}	0.28 ± 0.05^{a}	0.34 ± 0.03^{ab}	0.34 ± 0.04^{ab}	0.40 ± 0.04^{b}
Cu	0.15 ± 0.00^{a}	0.19 ± 0.01^{b}	0.73 ± 0.03^{d}	0.19 ± 0.00^{b}	0.25 ± 0.03^{c}	0.24 ± 0.00^{c}
Zn	0.56 ± 0.04^{a}	1.07 ± 0.04^{c}	0.73 ± 0.04^{b}	1.72 ± 0.02^{d}	0.74 ± 0.05^{b}	1.95 ± 0.05^{e}
Ca	0.13 ± 0.00^{b}	0.07 ± 0.01^{a}	0.28 ± 0.01^{d}	0.25 ± 0.02^{c}	0.45 ± 0.01^{f}	0.32 ± 0.02^{e}
Mn	0.02 ± 0.00^{d}	0.02 ± 0.00^{d}	0.01 ± 0.00^{b}	0.01 ± 0.00^{c}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
Ni	0.26 ± 0.00^{b}	0.13 ± 0.00^{a}	0.30 ± 0.00^{c}	0.14 ± 0.00^{a}	0.44 ± 0.00^{e}	0.33 ± 0.01^{d}
Mg	1.40 ± 0.01^{d}	1.42 ± 0.01^{e}	1.37 ± 0.02^{b}	1.41 ± 0.01^{de}	1.43 ± 0.00^{e}	1.40 ± 0.00^{d}
K	714.03 ± 8.82^{f}	717.50 ± 5.07^{f}	507.82 ± 3.28^{b}	466.52 ± 10.17^{a}	539.96 ± 10.59^{c}	580.33 ± 12.66^{d}
Na	11.65 ± 0.38^{de}	11.34 ± 0.37^{cd}	11.33 ± 0.32^{cd}	10.83 ± 0.06^{ab}	11.89 ± 0.12^{e}	10.59 ± 0.33^{a}
P	11.84 ± 0.12^{abc}	14.67 ± 0.28^{d}	11.44 ± 0.28^{abc}	10.93 ± 0.08^{ab}	10.33 ± 0.19^{a}	10.32 ± 0.32^{a}

Values are means of triplicate ± SD. Samples carrying the same superscripts in the same row are not significantly different at ($p > 0.05$). A, *P. ostreatus* cultivated on wood substrate (*Canarium* sp.) without fortification. B, *P. ostreatus* cultivated on wood substrate (*Canarium* sp.) fortified with zinc. C, *P. ostreatus* cultivated on wood substrate (*Ceiba pentandra*) without fortification. D, *P. ostreatus* cultivated on wood substrate (*Ceiba pentandra*) fortified with zinc. E, *P. ostreatus* cultivated on wood substrate (*Pycnanthus angolensis*) without fortification. F, *P. ostreatus* cultivated on wood substrate (*Pycnanthus angolensis*) fortified with zinc.

Table 2. Amino acid composition (g/100.g) of cultivated mineral fortified and non-mineral fortified *P. ostreatus*.

Amino acid	A	B	C	D	E	F
Alanine	3.56 ± 0.09^{a}	3.54 ± 0.02^{a}	3.56 ± 0.03^{a}	3.59 ± 0.01^{a}	3.76 ± 0.03^{b}	3.82 ± 0.03^{c}
Arginine	5.04 ± 0.02^{b}	5.04 ± 0.02^{b}	5.75 ± 0.02^{b}	5.79 ± 0.02^{b}	6.30 ± 0.02^{c}	6.35 ± 0.02^{c}
Aspartic acid	3.82 ± 0.02^{a}	3.93 ± 0.03^{a}	4.10 ± 0.02a^{b}	4.30 ± 0.01^{b}	4.32 ± 0.03^{b}	4.98 ± 0.03^{c}
Cystine	0.47 ± 0.02^{a}	0.49 ± 0.01^{a}	0.54 ± 0.02b	0.57 ± 0.02^{b}	0.54 ± 0.01^{b}	0.57 ± 0.02^{b}
Glutamic acid	9.09 ± 0.02^{a}	9.30 ± 0.03^{ab}	9.94 ± 0.01^{b}	9.96 ± 0.01^{b}	10.40 ± 0.20^{c}	11.17 ± 0.03^{d}
Glycine	0.44 ± 0.02^{a}	0.48 ± 0.02^{a}	1.54 ± 0.03^{b}	1.56 ± 0.01^{b}	1.64 ± 0.02^{c}	1.70 ± 0.01^{d}
Histidine	1.05 ± 0.02^{a}	1.05 ± 0.00^{a}	1.13 ± 0.03^{b}	1.12 ± 0.01^{b}	1.12 ± 0.03^{b}	1.17 ± 0.02^{b}
Isoleucine	1.12 ± 0.03^{a}	1.31 ± 0.03^{a}	1.21 ± 0.02^{b}	1.24 ± 0.02^{b}	1.24 ± 0.02^{b}	1.55 ± 0.01^{c}
Leucine	1.77 ± 0.02^{a}	1.97 ± 0.02^{a}	2.19 ± 0.02^{b}	2.32 ± 0.01^{b}	2.33 ± 0.02^{b}	2.70 ± 0.02^{b}
Lysine	1.42 ± 0.02^{a}	1.83 ± 0.01^{c}	1.44 ± 0.02^{a}	1.59 ± 0.01^{b}	1.48 ± 0.02^{a}	1.83 ± 0.02^{c}
Methionine	0.48 ± 0.01^{b}	0.48 ± 0.01^{b}	0.44 ± 0.02^{a}	0.47 ± 0.02^{b}	0.55 ± 0.02^{c}	0.59 ± 0.02^{d}
Phenylalanine	1.28 ± 0.02^{a}	1.35 ± 0.03^{b}	1.45 ± 0.01^{c}	1.46 ± 0.02^{d}	1.28 ± 0.02^{a}	1.31 ± 0.03^{b}
Proline	0.44 ± 0.02^{a}	0.48 ± 0.01^{b}	0.45 ± 0.03^{a}	0.47 ± 0.02^{b}	0.44 ± 0.01^{a}	0.48 ± 0.02^{b}
Serine	1.96 ± 0.02^{a}	1.99 ± 0.00^{b}	2.06 ± 0.02^{b}	2.08 ± 0.02^{b}	2.12 ± 0.02^{c}	2.19 ± 0.03^{d}
Threonine	2.10 ± 0.02^{a}	2.11 ± 0.01^{a}	2.27 ± 0.03^{b}	2.31 ± 0.02^{c}	2.30 ± 0.03^{c}	2.33 ± 0.01^{a}
Tyrosine	0.84 ± 0.03^{b}	0.82 ± 0.02^{a}	0.99 ± 0.02^{c}	1.00 ± 0.02^{d}	1.15 ± 0.02^{e}	1.20 ± 0.02^{e}
Valine	1.44 ± 0.02^{a}	1.44 ± 0.02^{a}	1.62 ± 0.02^{b}	1.63 ± 0.01^{b}	1.62 ± 0.02^{b}	1.69 ± 0.01^{c}

Values are means of triplicate ± SD. Samples carrying the same superscripts in the same row are not significantly different at ($p > 0.05$). A, *P. ostreatus* cultivated on wood substrate (*Canarium*sp) without fortification. B, *P. ostreatus* cultivated on wood substrate (*Canarium*sp) fortified with zinc. C, *P. ostreatus* cultivated on wood substrate (*Ceiba pentandra*) without fortification. D, *P. ostreatus* cultivated on wood substrate (*Ceiba pentandra*) fortified with zinc. E, *P. ostreatus* cultivated on wood substrate (*Pycnanthus angolensis*) without fortification. F, *P. ostreatus* cultivated on wood substrate (*Pycnanthus angolensis*) fortified with zinc.

highest Ca concentration. An earlier study showed that selenium fortification may have enhanced the absorption of Ca and Mg from the substrate[24]. Some researchers have also reported the ability of *Pleurotus* species to bioaccumulate elements such as selenium, zinc, lithium, calcium, and iron from the substrate on which they are cultivated[13,25,26]. Chang & Miles[27] had earlier reported that the mineral content in substrates can significantly affect the accumulation of minerals in mushrooms.

The presence of essential macro minerals (Mg, P, K, and Ca) and micro minerals (Na, Mn, Fe, Cu, Zn) in the mushroom, with potassium having the highest value (717.50 mg/100 g), implies that they could be utilized to maintain and improve health. This is similar to the observations of Oyetayo et al.[24] when they worked on the effects of selenium fortification on the mineral and fatty acid properties of *Pleurotus ostreatus*. However, addition of the minerals to the substrate showed a great significant increase in zinc contents of the fortified mushroom. This indicates that mushrooms absorb supplemented elements in their growth substrates. The ability of *Pleurotus* sp. to absorb mineral elements such as Se, Zn, Li, and Fe has been reported[28].

The observed significant differences ($p > 0.05$) in mineral content among different samples of *P. ostreatus* cultivated on various wood substrates highlight the importance of substrate composition and zinc fortification in influencing the nutritional profile of mushrooms. The finding correlates with previous research indicating the significant impact of substrate composition on mineral accumulation in mushrooms[5,28].

The result from the present research revealed notable variations in the amino acid composition of *P. ostreatus* across the different wood substrates and mineral fortification treatments. For instance, alanine content was significantly higher in mushrooms grown on *Pycnanthus angolensis* compared to *Ceiba pentandra* and *Canarium* sp. ($p < 0.05$). Similarly, fortification with zinc led to increased levels of histidine in all substrate types, with the highest concentration observed in *Pycnanthus angolensis* ($p < 0.05$). Previous studies have demonstrated that the amino acid profile of mushrooms varies depending on the cultivation conditions. For example, research by Chen et al.[29] found that substrate composition affects the accumulation of amino acids in mushrooms. Additionally, mineral fortification has been shown to enhance the nutritional quality of mushrooms. Studies by Silva et al.[30] stated the role of zinc in improving the amino acid content of edible fungi. Amino acids are essential nutrients that contribute to the nutritional value and flavour of edible mushrooms. They are also important indicators of mushroom quality and can be influenced by cultivation methods and environmental factors.

In conclusion, *P. ostreatus* cultivated on *Pycnanthus angolensis* spiced with zinc had the highest vitamin A content. Moreover, some of the essential amino acids in *P. ostreatus* cultivated on *Pycnanthus angolensis* spiced with zinc were higher than that obtained in other wood substrates used for cultivation. Overall, zinc fortification of *P. ostreatus* in synergy with wood substrates used for it cultivation significantly improved its nutritional value, making it a promising functional food that could address micronutrient deficiencies in humans. *P. ostreatus* enriched with zinc could therefore be used to solve the problem of zinc deficiency in food, which has been linked with stunted growth, poor appetite, and poor taste in children.

Ethical statements

This study did not involve human or animal subjects, and as such, ethical approval was not required.

Author contributions

The authors confirm their contributions to the paper as follows: Conceptualization, research design, writing – review and editing: Oyetayo VO; data interpretation, sample collection, data analysis, writing – original draft: Oyetayo VO, Ariyo OO; laboratory analysis and data collection: Ariyo OO. Both authors reviewed the results and approved the final version of the manuscript.

Data availability

All data generated or analyzed during this study are available from the corresponding author upon reasonable request.

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Conflict of interest

The authors declare that they have no conflict of interest.

Dates

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