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Improvement of nutritional composition of shiitake mushroom (*Lentinula edodes)* using formulated substrates of plant and animal origins

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A B S T R A C T

The cultivation of shiitake mushrooms (*Lentinula edodes*) is increasing rapidly due to their nutritional and medicinal benefits. Previously, we evaluated different substrates for cultivating L. *edodes* mushrooms but did not determine the impact of these substrates on the nutritional contents. Thus, the aim of this study was to evaluate the nutritional values of *Lentinula edodes* mushrooms cultivated on seven different substrates. Samples of fruiting bodies were oven-dried at 45°C for 72 h and grinded by a mill to a particle size of <1 mm. The milled fruiting bodies were analyzed following a well established methods. Accordingly, the nutritional composition and mineral elements of mushrooms cultivated on each of the substrate were determined using a Plasma Spectrophotometer and Microwave Plasma Atomic Emission Spectroscopy, respectively. The content of crude protein, crude fiber, crude fat, and carbohydrates were in the range of 13.67–19.60 %, 12.99–15.34 %, 0.77–1.83, and 52.17–59.39 %, respectively. The highest value of nutrients was obtained from sugarcane bagasse supplemented with poultry manures (S4), except carbohydrates from sugarcane bagasse alone (S1). Therefore, the use of plant substrates supplemented with animal origin improved the nutritional values of L. *edodes* mushroom in order to combat malnutrition and contribute to food security in the country.

Introduction

The incidence of food insecurity and malnutrition remained at critical levels in sub-Saharan Africa, including Ethiopia (Elkanah et al., 2022; Global Report on Food Crises (GRFC), 2022) and requires an abundant supply of cheap, accessible, and nutritious food for the burgeoning population (Fonseca et al., 2016). The global food system must incorporate long-term sustainability considerations because it is influenced by so many factors, including farming technology, politics, the environment, and the severe impacts of climate change (Platania and Santisi, 2015; Wasser, 2010). It is not only farm size constraints; critical shortages of fertile soil within African farming systems indicate that mineral fertilizers are applied but cannot sustain crops production due to deterioration of soil fertility (Fonseca et al., 2016; Tel-Çayan et al., 2021). Therefore, structure adjustments, alternative food source searches, and innovations in the diversification of nutritious food types with short life cycles are needed to maintain a healthy, resilient supply of affordable food for a growing and impoverished populations whose living conditions have been worsened by pandemics, climate change, and internal conflicts (Marco-Urrea et al., 2009) demanding innovative strategies for resilience.

Hence, among several ways, mushrooms cultivation and production remain a promising alternative in improving agricultural diversity to feed the affected populations to ensure a sufficient supply of protein and essential minerals to combat the incidence of malnutrition in order to provide a balanced healthy diet. Moreover, this approach is a good alternative for many women and young people to uplift themselves out of vicious poverty in developing countries like Ethiopia.

Mushrooms are macrofungi and many of them have been widely used as nutritive and medicinal products in developed countries to improve health and wellness (Bell et al., 2022). Many different mushroom species have diversified chemical compositions and nutritional values

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(Ruiz-Almenara et al., 2019). Apart from being excellent sources of crude protein, edible mushrooms have rich sources of dietary soluble fiber, essential minerals, complex polysaccharides, fat-free but high in essential unsaturated fatty acids (>75 %), vitamins B (B2 riboflavin, B9 folate, B1 thiamine, B5 pantothenic acid, and B3 niacin), and secondary metabolites, micronutrients and little energy (Zhao et al., 2022). However, edible mushrooms as novel food source, are one of the greatest untapped food item in Ethiopia since they can generate income for growing and poorer populations. This agribusiness is also highly important in job creation particularly to women and youngesters.

Lentinula edodes (Berk.) Sing., commonly known as the shiitake mushroom, is the second most popular edible mushroom in the world because of its alluring flavour and quality (Ozcelik and Peksen, 2007). In addition, *Lentinula edodes* mushroom is one of the best-known and characterized mushrooms used for medicinal purposes (Ooi and Liu, 2000) including antitumor (Minato et al., 1999), antioxidant (Choi et al., 2006), antiviral (Rincão et al., 2012), antibacterial (Hatvani, 2001), and low cholesterol content (Fukushima et al., 2001). L. *edodes* is also a type of white-rot wood decay fungus known to be the most efficient lignin degrader in nature. It naturally inhabits many dead woody tree species and uses natural logs as growth substrates but takes long time to produce fruiting bodies (Diehle and Royse, 1986).

Very recently, an attempt was made to develop more efficient, low cost, and sustainable growth substrates using agroindustrial byproducts supplemeted with animal manures that were optimized to increase the yield and nutritional composition of *Lentinula edodes* mushroom within short period of time (Desisa et al., 2023). Hence, supplementing sugarcane bagasse with poultry manure could be an option for cultivating *Lentinula edodes* mushrooms that gave a higher yield of fruiting bodies. However, the impact of these substrates on the nutritional content of *Lentinula edodes* was not evaluated. Consequently, findings from the present study will serve as a valuable foundation for more comprehensive comparisons with similar research in the future. The incorporation of supplements in the course of mushrooms cultivation has reported to expedite or boost the enhancement of nutritional contents and quality of fruiting bodies of the cultivated mushrooms better than when grown on a single substrate alone (Desisa et al., 2023; Landi et al., 2022). Hence, this study aimed to evaluate the nutritional composition of shiitake mushroom (*Lentinula edodes*) using formulated substrates of plant and animal origins.

Materials and methods

Materials

Fresh *Lentinula edodes* mushroom culture was obtained from the Forest Product Innovation mushroom farm Center (Ethiopian Forestry Development) in Addis Ababa, Ethiopia, and grown on seven triplicate substrates (S1-S7) formulated from sugarcane bagasse alone and supplemented with cow dung, horse and poultry manures, canesugar trash, and filter cake. The experimental design was conducted according to the study of Desisa et al. (2023) (Table 1). The 500 g (wet weight) of substrates were placed inside heat-resistant polypropylene bags and subjected to sterilization in an autoclave at 121°C for 15 min. Following sterilization, the substrates were inoculated with 3% fresh *Lentinula edodes* spawn, equivalent to 15 g for every 500 g of substrates per polypropylene bag. Thereafter, the bags were sealed before being transferred to a dark incubation room for the spawn running stage by maintaining a temperature of 25°C and relative humidity of 85 ± 5%. After 26–35 days, the substrates were entirely covered with mycelium, and a dark-brown crust was formed. Subsequently, the bags were exposed to light for 12 h daily in a controlled room with a temperature of 18 ± 2°C and 80–90% relative humidity to induce fructification. Harvesting of shitake conducted when the fruit bodies showed full maturity and exposure of gills. The entire process was iterated for three to five flushes as explained in Desisa et al. (2023). For nutritional analysis, samples of fresh fruiting bodies were oven-dried at 45°C for 72 h and grinded by a mill (RRH-500A, Zhejiang, China), a high-speed multi-function comminutor with a screen that was given a particle size of <1 mm.

Table 1
Substrate formulations for the cultivation of *Lentinula edodes* (Desisa et al., 2023).

Substrates	Formulation (100 %)
S1	100 % sugarcane bagasse alone
S2	80 % Sugarcane bagasse + 20 % Cow dung
S3	80 % Sugarcane bagasse + 20 % Horse manure
S4	80 % Sugarcane bagasse + 20 % chicken manure
S5	80 % Sugarcane bagasse + 20 % Cotton seed hull
S6	80 % Sugarcane bagasse + 20 % Sugarcane filter cake
S7	80 % Sugarcane bagasse + 20 % sugarcane trash

Analysis of nutritional composition

Samples preparation for the analyses of the studied parameters were done following the methods of Desisa et al. (2023). Total ash and moisture contents in mushrooms were determined according to the Ethiopian Conformity Assessment Enterprise test (ES1032–1:2005) using an Agilent 4200 Series MP-AES Inductively Coupled Plasma spectrophotometer (Agilent Technologies, Santa Clara, CA, USA). This is adopted from the Association of Official Analytical Chemists procedures method (1984) for ash and moisture content, respectively (Thiex et al., 2012;, AOAC 1995). The total crude protein contents were evaluated by the Macro Kjel-dahl method according to the method of BCTL/SOP/M014.01 (ES1032–1:2005) adopted from the USDA (2009) national nutrient database. Fiber contents were measured by BCTL/SOP/M017.01, adopted from ISO 5498, agricultural food product analysis manual (ES1032–1:2005). Fat contents were determined by the soxhlet extraction technique described by Srigley and Mossoba (2016). The total carbohydrates were calculated by the difference: total carbohydrates =100 − (moisture + protein + fat + ash) (Fernandes et al., 2015). Three measurements were made in the analysis of the nutritional and mineral compositions of *Lentinula edodes* mushrooms.

Analysis of mineral contents

The analysis of mineral elements (Mg, K, P, Ca, Na, Mn, Zn, Fe, and Ni) in mushroom fruiting bodies were determined according to the Ethiopian Standards under the direction of Food Technology by the Quality and Standards Authority of Ethiopia (QSAE) and quantified according to EPA 6020B, Modified Microwave Plasma Atomic Emission Spectroscopy (MP-AES).

Statistical analysis

Experimental data were analyzed using analysis of variance (ANOVA) with SPSS (version 28) statistical software. Data were presented as means ± standard deviation (SD) of triplicate samples using Duncan's test ($p < 0.05$).

Results and discussion

Nutritional contents of Lentinula edodes mushroom

According to the statistical analysis in Table 2, *L. edodes* was found to have a significant ($p < 0.05$) difference in ash contents (Table 2). The highest content of ash was found in the mushroom growing on S2 (6.50%), but the lowest ash content was found in S6 (5.23%). These results were similar to the findings of Chaipoot et al. (2023) who found the closest values from analysis of L. *edodes* mushroom fruiting bodies. The L. *edodes* mushrooms that grew on the formulated substrates

Table 2
Nutritional composition of *Lentinula edodes* mushrooms.

Substrates	Nutritional composition (% dry weight)					
	Total ash (%)	**Moisture content (%)**	**Crude protein (%)**	**Crude fiber (%)**	**Crude fat (%)**	**Carbohydrate (%)**
S1	5.76 ± 0.05^{c}	$\mathbf{5.73\pm0.35^{ab}}$	13.67 ± 0.40^{f}	13.97 ± 0.65^{bc}	1.48 ± 0.31^{c}	$\mathbf{59.39\pm0.31^{a}}$
S2	$\mathbf{6.50\pm0.17^{a}}$	6.06 ± 0.55^{ab}	19.30 ± 0.51^{a}	$\mathbf{12.99\pm1.55^{c}}$	0.88 ± 0.10^{de}	54.27 ± 0.05^{e}
S3	6.20 ± 0.10^{b}	5.76 ± 0.15^{ab}	16.18 ± 0.04^{d}	14.28 ± 1.01^{bc}	1.51 ± 0.10^{bc}	56.07 ± 0.57^{b}
S4	5.26 ± 0.05^{de}	5.80 ± 0.10^{ab}	$\mathbf{19.60\pm0.20^{a}}$	$\mathbf{15.34\pm0.39^{b}}$	$\mathbf{1.83\pm0.38^{a}}$	$\mathbf{52.17\pm0.01^{e}}$
S5	5.43 ± 0.05^{de}	$\mathbf{6.23\pm0.05^{a}}$	17.32 ± 0.14^{c}	13.81 ± 0.63^{bc}	1.10 ± 0.04^{d}	56.11 ± 0.05^{b}
S6	$\mathbf{5.23\pm0.05^{f}}$	5.70 ± 0.10^{b}	18.19 ± 0.34^{b}	14.15 ± 0.70^{bc}	$\mathbf{0.77\pm0.10^{e}}$	55.96 ± 0.54^{c}
S7	5.46 ± 0.11^{d}	5.86 ± 0.05^{ab}	$\mathbf{15.27\pm0.05^{e}}$	18.00 ± 0.48^{a}	1.73 ± 0.02^{ab}	53.68 ± 0.45^{d}

Data are expressed as the means ± standard deviation (SD), and the same letter within the same row are not significantly different ($p < 0.05$).

exhibited nutritional values that were significantly ($p< 0.05$) different (Table 2). The percentage of crude protein varied depending on the substrate formulations, and all of the treatments had a good amount of protein. The protein content obtained in this study ranged from 13.67 to 19.60 % (Table 2). Sugarcane bagasse alone (S1) provided the least amount of protein (13.67%), while sugarcane bagasse mixed with poultry manure (S4) provided the highest (19.60%) crude protein content. This is higher than *Lentinula edodes* crude protein contents (17.48%) grown on different agricultural wastes containing peat moss, banana leaves, oak sawdust, millet seed, cotton seed hull and $CaCO_3$ (Cobos et al., 2021) and promising crude protein content (13.8%) was obtained from sugarcane alone (Kumla et al., 2020). This value is higher than common food items such as rice (7.3%), wheat (13.2%), but lower than soybean (39.1%). The protein content (this study) is comparable to milk (25.2% (Alam et al., 2008) and by far higher than vegetables (Butnariu and Butu, 2014). The results of this study are similar to those of Rahman and Choudhury (2013) who stated that the protein content of L. *edodes* mushrooms was 20–23% with digestibility of 80–87%. The substrate composition of locally grown mushrooms had an impact on the protein content of the mushrooms depending on the growth substrate (Onyeka and Okehie, 2018). As a result, high protein content obtained from mushrooms cultivated on the supplemented substrates could be due to the richness of carbon and nitrogen in the supplements added (Elkanah et al., 2022).

The fiber content of L. *edodes* fruiting bodies ranged from 13.9 to 18% (Table 2). In contrast, the lowest crude fiber content (1.5%) was obtained from L. *edodes* grown on rice straw alone (Kumla et al., 2020). Cristiane Vieira Helm et al. (2019) have analyzed L. *edodes* grown on AS (sawdust and eucalyptus brush, wheat bran, corn germ and limestone) and obtained the highest result for total dietary fiber content (39.16%). This fungal fiber is mostly soluble and can be absorbed in human gut, in contrast to plant fiber, which primarily consists of cellulose or hemi-cellulose that cannot be utilized by humans. Fiber is evolving as a crucial food component from the perspective of contemporary nutrition (Cheung, 2013). Up to 25% of the daily necessary intake of dietary fiber can readily be obtained by eating edible mushrooms as part of our diet (Cheung, 2013). Additionally, fiber is beneficial for human health because it does not only aid in digestion but also works to prevent disease by serving as prebiotics to gut microbes (Li et al., 2018).

The low-fat contents of L. *edodes* were observed in all the substrate formulations used in this study showing that this mushroom is a food source with a lower caloric value (Table 2). The low-fat content obtained in this study agrees with the report of the previous investigations (Elkanah et al., 2022). The results were generally low (0.77–1.83 %) and similar to the study of Onyeka and Okehie (2018), who found that mushrooms are low sources of dietary fat. This is lower than the findings reported by Rahman and Choudhury (2013) that ranged from 3 to 4% L. *edodes* mushrooms but higher (2.82%) than L. *edodes* produced on the combination of sawdust and eucalyptus brush, wheat bran, corn germ and limestone (Cristiane Vieira Helm et al., 2019). The most important function of lipids in human bodies is to produce energy for muscle and body activities to maintain body temperature, support digestion, and absorb food nutrients (Elkanah et al., 2022). Hence, eating L. *edodes* mushrooms for their high nutritional values with very little fat (1.22 %) and no cholesterol content is arousing interest worldwide for consumption of this macrofungus (Bich Thuy Thi et al., 2021; Gao et al., 2020).

Mushroom that grew on sugarcane bagasse alone (S1) had the highest carbohydrate content (59.39 %). The bioconversion of carbohydrates in the colonized substrates into mycelia protein could explain the reason for decrease or increase in carbohydrates seen with the addition of a specific proportion of additives (Elkanah et al., 2022). The total carbohydrate content obtained in this study indicates that mushrooms are good sources of energy, which agrees with the finding by Dimopoulou et al. (2022) who reported carbohydrate values that ranged from 58 to 60%. However, carbohydrate values obtained in this study were higher than the previous study 43.96% (Li et al., 2018) and lower than L. *edodes* cultivated on sugarcane bagasse alone 73.0–78.9% (Kumla et al., 2020). Numerous studies have revealed the anticancer, antiviral, and antioxidant activities of L. *edodes* mushroom polysaccharides to lessen or avoid the suppression of immunological lymphocytes by chemotherapeutics (Akcay et al., 2023; Gao et al., 2020; Harith et al., 2014). Additionally, the main glucose polymers present in L. *edodes* mushrooms are glucans (Bak et al., 2014). As a result, it was also a wise decision to extract the polysaccharides from shiitake mushrooms in order to create polysaccharides for oral liquid, pill, or injection (Li et al., 2018). Accordingly, the key determinants affecting the nutritional composition of mushrooms is substrate composition (Elkanah et al., 2022). The better performance obtained in using sugarcane bagasse and poultry manure as an additive could be due to their rich balanced nutritional content of carbon and nitrogen sources (Desisa et al., 2023). In addition to nutritious proteins, L. *edodes* has long been known to include a wide range of biologically active components including dietary fibers, lipids, and minerals (Cunha et al., 2011; Dhakar and Pandey, 2013) as well as vitamins and fatty acids (Ramezan et al., 2021; Cunha et al., 2011).

Minerals

L. *edodes* mushrooms grown on sugarcane bagasse and horse manure had the greatest Mg content (1200.01 mg/kg), which is similar to the study of Li et al. (2018) on the Mg content (1209.56 mg/kg) of the mushrooms. Mineral elements play an important role in metabolism as they are needed for various metabolic responses such as the formation of strong bones, water regulation and saline balance, sensory stimulation, and other functions (Assemie and Abaya, 2022). The differences in the concentrations of mineral elements depend on the substrate used during growth. The substrate used in the cultivation of the mushroom significantly ($p<0.0.05$) affected the mineral content of the harvested mushroom (Tables 3 and 4). A variety of essential macro-mineral elements (Mg, K, P, Ca, and Na) and trace mineral elements such as Mn, Zn, Fe, and Ni were found in L. *edodes* mushrooms. These minerals are crucial for human physiological function, cell metabolism, and biosynthesis (Li et al., 2018). The highest K (20,000 mg/kg), Ca (334.41 mg/kg) and Na

Table 3
Macro-mineral elements of *Lentinula edodes* mushrooms [mg/kg dm].

Substrates	Metals				
	Mg	**K**	**P**	**Ca**	**Na**
S1	1124.16 ±1.17[c]	11,929.33 ±0.14[c]	455.00 ±1.73[c]	141.66 ±17.24[c]	211.00 ±1.23[c]
S2	1012.33 ±0.57[b]	17,476.33 ±0.85[b]	540.00 ±4.19[b]	184.66 ±15.9[4a]	191.00 ±1.54[d]
S3	**1200.01 ±0.25[a]**	16,912.33 ±0.10[b]	460.66 ±5.68[c]	153.33 ±3.05[a]	213.66 ±1.15[c]
S4	1145.66 ±1.15[b]	**20,000.11 ±0.57[a]**	**577.33 ±3.17[a]**	**334.41 ±2.06[a]**	**290.00** ±1.29[a]
S5	916.33 ±0.57[g]	17,189.00 ±0.13[b]	**600.00 ±1.06[a]**	285.16 ±0.59[a]	240.00 ±2.64[b]
S6	1061.66 ±6.80[d]	17,484.33 ±0.63[b]	446.00 ±1.47[cd]	249.18 ±1.57[a]	238.66 ±7.23[b]
S7	1023.33 ±0.57[e]	16,643.00 ±1.02[d]	413.33 ±0.57[d]	234.66 ±5.02[a]	177.66 ±1.52[e]

Data are expressed as the means ± standard deviation (SD), and the same letter within the same row are not significantly different at ($p < 0.05$).

Table 4
Trace mineral elements of *Lentinula edodes* mushrooms [mg/kg dm].

Substrates	Metal			
	Mn	**Zn**	**Fe**	**Ni**
S1	16.66±0.15[b]	35.16±0.59[b]	17.33±0.05[c]	0.04±0.13[c]
S2	15.76±0.05[c]	67.88±0.47[a]	14.20±0.01[f]	0.04±0.27[b]
S3	13.60±0.01[e]	70.24±0.01[a]	16.04±0.05[d]	0.03±0.01[d]
S4	12.56±0.05[f]	75.15±0.02[a]	**20.00±0.05[a]**	**0.05±0.01[a]**
S5	11.76±0.05[g]	66.54±0.01[a]	18.10±0.01[b]	0.02±0.18[e]
S6	**17.50±0.37[a]**	**77.50±0.23[a]**	15.00±0.19[e]	0.03±0.36[d]
S7	15.44±0.60[d]	68.66±0.41[a]	12.36±0.06[g]	0.01±0.25[f]

Data are expressed as the means ± standard deviation (SD), and the same letter within the same row are not significantly different at ($p < 0.05$).

(290 mg/kg) levels were found in the mushrooms grown on a mixture of sugarcane bagasse and poultary manures (Table 3), which were higher than those found in the findings of Mau et al., al.(2021) and similar with study of Siwulski et al. (2019) where L. *edodes* mushrooms produced on wheat bran is formulated with corn meal, millet and other additives. Additionally, the sugarcane bagasse and cotton seed hull combinations (S5) produced fruiting bodies with the highest P (600 mg/kg) contents. Calcium is a mineral found in mushrooms that is essential for human nerve and muscle function, as well as for the growth and maintenance of bones in the body of the consumers (Elkanah et al., 2022).

In this study, L. *edodes* mushrooms were rich in essential trace mineral elements such as manganese, iron, zinc, and nickel and significantly ($p < 0.05$) affected by the growth substrates (Table 4). Hence, L. *edodes* mushrooms grown on sugarcane bagasse and sugarcane filter cake (S6) had the greatest Mn (17.50 mg/kg) and Zn (77.5 mg/kg) concentrations. The Mn content of the L. *edodes* mushroom obtained in this study is lower than the value reported by other investigators (Ozcelik and Peksen, 2007) but similar to the amount of Mn and Zn found in L. *edodes* mushrooms reported by Li et al. (2018). The highest Fe (20 mg/kg) and Ni (0.05 mg/kg) contents were attained from the mushroom cultivated on sugarcane bagasse supplemented with poultry manures (S4) but lower than the one reported by Assemie and Abaya, 2022), whose Fe content measured as 37.55 mg/kg.The S4 (80% sugarcane bagasse and 20% poultry manure) substrate had a higher Fe content than the mushrooms grown on other substrates. However, low Fe content (12.36 mg/kg) was detected in S7. High and low levels of Ni (0.05 mg/kg and 0.01 mg/kg), respectively, were detected in S4 and S7.

The variations observed in the mineral content of L. *edodes* mushroom may be due to the difference in the biological and chemical composition of the growth substrates (Ozcelik and Peksen, 2007; Rahman and Choudhury, 2013). According to Zakil et al. (2020) and Elkanah et al. (2022), mushrooms derive their food from the growth substrates, hence the observed variations could be explained largely on the basis of mineral composition of different substrates utilized during the cultivation processes. Correspondingly, the data from this research demonstrate that cultivated mushrooms could be a good source of many dietary minerals. L. *edodes* mushrooms that could be utilized as beneficial supplement due to their high calcium and zinc contents, mainly when used to produce dietary options for older adults and growing youngsters (Li et al., 2018). Sodium and potassium are crucial in preserving the osmotic equilibrium in animal systems between intestinal fluid and cells. Edible mushrooms are effective at lowering blood pressure, reducing the risk of osteoporosis, and maintaining bone health (Bell et al., 2022). Additionally, eating mushrooms lowers the chance of developing high blood pressure and cardiovascular disorders due to their high potassium and low Na salt content (Valverde et al., 2015). Adequate intake of mineral is required for nearly all metabolic, developmental, and growth processes as well for a good health and prevention of deficiency related diseases and reduces the problem of malnutrition (Blumberg et al., 2017).

Micronutrient inadequacies are associated with adverse health effects such as neural tube defects, poor bone health (osteoporosis), impaired immune function, and impaired cognitive function, as well as chronic diseases such as certain cancers, age-related eye diseases, hypertension, and possibly coronary heart disease and stroke (Valverde et al., 2015; Ames, 2006). Low intakes of calcium, potassium, iron (adolescent and adult females), dietary fiber, and vitamin D have been linked in the scientific literature to adverse health outcomes and hence are considered nutrients of public health concern (Blumberg et al., 2017). However, the result from this study revealed that the harvested mushrooms cultivated on the different formulated substrates could be a good source of many dietary minerals. Eating *Lentinula edodes* mushrooms is a good choice for protein and other basic mineral elements for improving health by combating malnutrition. Because of plant and animal proteins are deficient in one or more essential amino acids and cannot be considered complete proteins (Sá et al., 2020). Recently, edible mushrooms are being recognized as safe sources of high-quality proteins at a low cost, faster, and with little to no negative environmental impact that would be much preferred to solve the problem of rising protein demand globally (Ayimbila and Keawsompong, 2023).

In addition, the consumption of these edible mushrooms in the diet could be an excellent source of iron, zinc, and other micronutrients, even for groups of the population with high nutritional requirements such as pregnant women and children (Gernand et al., 2016). Generally, it can be deduced from this study that supplemented substrates produced mushrooms with better nutritional and miniral contents than the non-supplemented substrate (Sugarcane bagasse alone) . This study may contribute to the better application of L. *edodes* as functional, nutraceutical foods, or pharmanutrients supporting health and wellness of human beings.

Conclusion

This study shows that varied combinations of sugarcane bagasse with poultry manure, cow dung, horse manures, filter cake and cotton seed hull had a substantial impact on the nutritional composition of L. *edodes* mushrooms and produced the desired mushroom nutrients profile. Sugarcane bagasse substrate supplemented with poultry manures gave the highest nutritional content of crude protein, crude fiber, and low fat with other necessary mineral elements. This can be recommended as suitable substrate for enhancing the nutrient compositions of the L. *edodes* mushrooms. The results demonstrated that using sugarcane bagasse is a potential substrate for L. *edodes* mushroom cultivation and offers the possibility of lowering production costs and new alternatives substrates for mushroom growers with improved nutrients. Consumption of L. *edodes* mushrooms can significantly contribute to the nutritional needs of people, especially in rural areas of Ethiopia which combats the increasing problem of malnutrition in the country.

Ethical approval and consent to participate

By signing below, we, the undersigned, approve and agreement to the release of identifying information, including in the entirety of the study report to be published in the Journal. We commit to acting honestly, faithfully, and with integrity. We shall make commitments that we intend to uphold and take full ownership of our actions. No malicious injury to another person or animal will be done on purpose by us or anyone else who participates in our research paper.

Consent for publication

We are aware that all Heliyon under Elsevier journals might be accessible in print and online, as well as to a larger readership via marketing channels and other third parties. So, anyone can read everything that is published in the Journal. We are aware that readers can include not just academic scholars but also journalists and regular citizens. As a result, we accepted the conditions and indicated guidelines.

Availability of data and materials

Data are accessible and can be sent to the concerned entity upon request.

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Ethical statement–studies in humans and animals

The presented work does not involve human and animal subjects.

CRediT authorship contribution statement

Buzayehu Desisa: Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing, Conceptualization, Data curation. **Diriba Muleta:** Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Formal analysis, Validation, Writing – review & editing. **Mulissa Jida:** Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing – review & editing. **Tatek Dejene:** Funding acquisition, Methodology, Resources, Formal analysis, Writing – review & editing. **Abayneh Goshu:** Funding acquisition, Resources, Formal analysis, Supervision, Project administration. **Tadesse Negi:** Resources, Supervision. **Pablo Martin-Pinto:** Funding acquisition, Methodology, Resources, Supervision, Validation, Writing – review & editing.

Declaration of competing interest

All the authors have approved the Ms and given their consent for submission and publication of this work. There is also no conflict of interest among the contributing authors.

Data availability

Data will be made available on request.

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