Food Chemistry Advances 11 (2026) 101274

Contents lists available at ScienceDirect

Food Chemistry Advances

journal homepage: www.elsevier.com/locate/focha

Nutritional content assessment of selected wild edible mushroom species and its comparison to cultivated mushroom species in Tanzania

Anna Minja Arturu [a,*], Marco E. Mng'ong'o [b]

[a] Department of Food Science and Technology, Mbeya University of Science and Technology, P.O. Box 131, Mbeya, Tanzania
[b] Department of Crop Science and Horticulture, Mbeya University of Science and Technology, P.O. Box 131, Mbeya, Tanzania

ARTICLE INFO

Keywords:
Proximate composition
Food preservation
Indigenous knowledge
Dietary diversification
Tanzania

ABSTRACT

Wild mushrooms are recognised for their nutritional and economic importance; however, their potential in Tanzania remains undocumented and underutilised. The present study assessed the nutritional composition of wild and cultivated mushroom species, the impacts of drying on nutrient retention, and the integration of indigenous species into local food systems. We studied seven (7) mushroom species, i.e., five wild edible species (*Cantharellus symoensii, Cantharellus afrocibarius, Amanita loosei, Lactarius kabansus,* and *Lactarius xerampelinus*) and two cultivated varieties (*Pleurotus ostreatus* and HKP Uyole). Samples were collected from Mlele Forest in the Katavi Region and the Mbeya Region. Proximate analyses were conducted on fresh and dried samples to determine moisture, protein, fat, fibre, ash, and carbohydrate contents. Wild mushrooms exhibited higher nutritional value, with protein content reaching up to 38.6%, crude fibre up to 17.6%, and total ash up to 14.1% compared to cultivated varieties. Higher moisture content (90–92%) in wild mushrooms led to rapid spoilage and shorter shelf life (from hours to 4 days). Drying significantly extended shelf life of mushrooms and retains most nutrients, although some reduction in protein content was observed. This study uniquely integrates nutritional profiling, processing effects, shelf-life analysis and taxonomic documentation to highlight species-specific differences between wild and cultivated edible mushrooms in Tanzania and contributes evidence to inform food security and nutrition strategies.

Introduction

Mushrooms are increasingly recognised as sustainable food resources with significant nutritional and medicinal value (Idrees et al., 2019; Adedokun et al., 2022). Globally, they are valued for their high protein content (Yuliana et al., 2024), dietary fibre, vitamins, minerals, and bioactive compounds with antioxidant properties (Chelela et al., 2014, 2015; Hussein et al., 2015; Juma et al., 2016; Mdachi et al., 2004; Mshandete & Cuff, 2007; Nteziryayo et al., 2019; Tibuhwa, 2013). In Tanzania, local native wild edible mushrooms have traditionally been consumed by various communities, particularly during the rainy season when they are abundantly available (Härkönen et al., 2003). Despite their cultural significance, national per capita mushroom consumption remains low, as mushrooms are used as supplementary foods rather than staple foods (Kivaisi, 2007). However, fresh mushrooms are highly perishable due to their high moisture content, which accelerates microbial growth and enzymatic deterioration. This results in a very short shelf life, often ranging from only a few hours to a few days under ambient conditions, thereby limiting marketability, distribution, and household utilisation.

Malnutrition remains a persistent public health challenge in Tanzania. Stunting affects 34% of children nationwide, and micronutrient deficiencies are widespread: 70% of children aged 6–59 months are zinc deficient, 58% are anaemic, and 34% lack adequate vitamin A intake (TNNS, 2018). Additionally, 59% of the population cannot afford a balanced diet, relying primarily on calorie-dense staples such as grains and cereals (WFP, 2024). Given their high nutrient density, mushrooms have the potential to contribute to dietary diversification and improved micronutrient intake (Barroetaveña & Toledo, 2016). However, a paradox persists; the availability of nutrient-rich mushrooms coincides with high levels of malnutrition. This situation highlights limitations in their effective dietary integration. Contributing factors include seasonal availability, limited cultivation, low awareness of their nutritional benefits, inadequate integration into household diets and post-harvest losses associated with their short shelf life.

To address seasonal constraints, cultivated mushrooms, particularly

* Corresponding author.
E-mail address: anna.arturu@must.ac.tz (A.M. Arturu).

https://doi.org/10.1016/j.focha.2026.101274
Received 31 July 2025; Received in revised form 9 March 2026; Accepted 10 March 2026
Available online 11 March 2026
2772-753X/© 2026 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Pleurotus ostreatus (oyster mushroom have been promoted by the Tanzanian government and NGOs as a strategy to enhance food security, increase household income, and reduce deforestation (Mwita et al., 2011). Nevertheless, consumption remains localised and limited in quantity. Preservation techniques are therefore critical to extending availability beyond the rainy season. Drying is the most common preservation method that extends mushroom shelf life beyond harvest seasons and ensures food availability during the dry season. It reduces moisture content and concentrates nutrients, such as protein, fibre, and minerals (Ratti, 2001). However, the drying method employed can influence nutritional quality, asheat-sensitive vitamins and bioactive compounds may be degraded. Traditional sun or air drying, widely practised in rural areas, often involves prolonged exposure to heat and environmental contamination, potentially compromising both nutritional quality and safety (Rai & Arumuganathan, 2008).

Beyond nutritional and processing challenges, taxonomic uncertainty further limits mushroom utilisation, further limits the utilisation of mushrooms. Despite the availability of various mushroom species in Tanzania, there is a critical lack of systematic identification and documentation of wild edible mushrooms. Traditional knowledge is largely passed down orally, leading to inconsistent identification, potential poisoning incidents, and underutilization of nutrient-rich species (Watling et al., 2002). Moreover, while mushrooms are nutritionally beneficial, they can also accumulate heavy metals and other potentially toxic compounds, underscoring the importance of accurate identification and scientific evaluation. This lack of scientific documentation limits safe consumption, market development, and evidence-based dietary promotion strategies. Therefore, this study was designed to fill key knowledge gaps by (i) analysing nutritional composition (protein, fat, fibre, ash, and carbohydrates) of selected wild and cultivated mushrooms in Tanzania, (ii) evaluating the effect of drying on the nutritional properties of these mushrooms, (iii) shelf life analysis and (iv) identifying and documenting the scientific names of selected wild species to align with standard mycological classifications. This integrated approach combines nutritional profiling, processing effects, shelf-life assessment observation, and taxonomic documentation. This study provides a comprehensive assessment of species-specific differences between wild and cultivated edible mushrooms in Tanzania and contributes evidence to inform food security and nutrition strategies.

Materials and methods

Study area

The present study was conducted in the Katavi and Mbeya regions of Tanzania. Samples were collected from Mlele Forest located between latitudes 6°–7°S and longitudes 31°–32°E. Mlele Forest is a biodiversity-rich miombo woodland ecosystem known for its diverse edible mushroom species due to its high rainfall, undisturbed forest cover, and rich organic soils (see Supplementary (S) Figure S2). The region experiences a tropical savannah climate with an average annual rainfall of 800–1200 mm and temperatures ranging from 18 to 30 °C, creating favourable conditions for wild mushroom growth during the rainy season. Cultivated mushroom samples were sourced from urban mushroom farmers in the Mbeya region, located at latitudes 7°–9°S and longitudes 33°–35°E. Mbeya has a bimodal rainfall pattern with annual precipitation of 900–2600 mm and moderate temperatures (16°–25 °C), which supports year-round oyster mushroom cultivation. These urban farmers specialise in the commercial production of *Pleurotus ostreatus* (oyster mushroom), supplying local markets and restaurants. Wild mushroom samples were collected from Mlele Forest, while cultivated mushrooms were obtained from urban farmers in Mbeya.

Selection criteria and justification

The present study considered five wild mushroom species and two cultivated varieties, each analysed in both fresh and dried forms. For each species, 2000 g of edible wild mushrooms were collected based on the availability and local consumption patterns. While 1000 g of the cultivated varieties included *Pleurotus ostreatus* (White Oyster mushroom) and an identified cultivated variety from the Tanzania Agricultural Research Institute (TARI)-Uyole. This quantity was considered sufficient for proximate nutrient analysis. The five wild edible mushroom species included in this study were selected based on their high cultural significance and widespread consumption among communities in southwestern Tanzania, as identified through local knowledge and market surveys (Table S1). Species such as *Lactarius kabansus* ("Umpalala") and *Cantharellus afrocibarius* ("Wange Njano") are particularly valued as delicacies and often command high market prices due to their unique flavours and seasonal scarcity. *Amanita loosii* ("Ulelema") and *Cantharellus symoensii* ("Wange Nyekundu") are also widely preferred for household consumption and form an important part of traditional diets during the rainy season (see Supplementary (S) Table S1). The cultivated oyster mushroom (*Pleurotus ostreatus*) was included due to its growing economic importance as a commercially produced mushroom promoted by the government and non-governmental organisations to enhance food security, household nutrition, and income generation.

Sample collection

Wild mushrooms were collected from naturally abundant areas with attention to maturity, freshness, and local naming conventions, supporting accurate species identification. The collection was assisted by experienced local harvesters, and preliminary identification relied on local knowledge and field photographs. Cultivated mushroom samples were sourced from farmers operating in Airport Street and Riverside areas of Mbeya City. These farmers are part of Rikolto Tanzania's initiative to promote sustainable urban farming systems, actively working to advance mushroom value chains for improved nutrition and household income (Rikolto, 2024). Expert informants were purposively selected based on their extensive knowledge and experience in wild mushroom identification, use, and collection practices. A total of six expert informants participated in the study. These included four elderly community members (aged 55–73 years) renowned locally for their traditional knowledge of edible wild mushrooms, and two regional mycologists with formal training in fungal taxonomy and identification. Community experts were identified through local leaders and snowball sampling within the Katavi region, while the mycologists were consulted from Mbeya University of Science and Technology (MUST).

Sampling collection procedure

Mushroom samples were collected by identifying mature specimens of the selected edible wild and cultivated mushroom species. For wild mushrooms, the collection process involved cutting fruiting bodies at the base of the stem near the volva and carefully cleaning any dirt or soil from the ground using clean knives. All samples were collected at full maturity to ensure optimal nutrient concentration. During collection, the mushrooms were placed in ventilated bags to maintain freshness and prevent moisture accumulation. After each round of collection, the samples were placed in a cool box with ice to preserve their quality and integrity before further processing.

Sampling frequency, handling and preservation

For wild mushroom species, approximately 2000 g per species were collected over two days. Of this, 1000 g were dried using solar dryers in Utende Village to preserve quality, while the remaining 1000 g of fresh samples were stored in cool boxes, transported to MUST and refrigerated at −1 °C to 1 °C within 36–48 h. These amounts were considered sufficient for comprehensive proximate nutrient analysis requirements, representation and any unforeseen contingencies during the study. For

cultivated mushrooms (Pleurotus ostreatus), 1000 g of fresh mushrooms were collected per sampling. Of this, 500 g were stored fresh in the refrigerator at −1 °C to 1 °C within 2 h, while the remaining 500 g were dried using food-grade dryers at 40 °C for 24 h, ensuring minimal nutrient loss. Both wild and cultivated mature mushrooms were collected using a purposively yet randomly distributed sampling approach within the respective sampling areas to ensure proper representation and sample quality for subsequent analysis. Fresh samples were stored in coolers with ice packs to prevent nutrient degradation, while dried samples were processed using solar drying (uncontrolled conditions) and a food-grade dryer (40 °C for 24 h). All samples were labelled and documented with scientific references for accurate species identification (Figure S1).

Research design

An observational study was conducted on five selected edible wild mushroom species. Species identification was initially based on local knowledge, morphological observation, and local names provided by community members. To ensure accurate documentation and facilitate future comparisons, photographs were taken at different stages of the identification process. Each sample collected was clearly labelled with its corresponding local name, collection date, and location details. For scientific identification, the study utilized the reference book "Wild Edible Mushrooms from Western Tanzania" by Peter Bloesch, which provides taxonomic keys, illustrations, and detailed descriptions of regional mushroom species (Bloesch, 2021). This approach ensured that species identification was both locally informed and scientifically rigorous.

Laboratory characterization and analysis

Laboratory analysis was conducted using proximate analysis to determine moisture, crude protein, crude fat, crude fibre, ash and carbohydrate content in each mushroom sample using standard analytical methods.

Moisture content: Moisture content was measured using a moisture analyzer operating based on the thermogravimetric principle. About one (1) gram of each sample was taken and analyzed for moisture content according to the Association of Official Analytical Chemists (AOAC) method (Balan et al., 2018).

Crude protein: Crude protein was estimated using the Kjeldahl method according to AOAC Official Method 984.13 (AOAC, 2005). Mushroom samples were first dried in a hot air dryer until a texture suitable for grinding was achieved. One (1) gram of the ground mushroom sample, along with a control sample (laboratory starch), was weighed and mixed with 0.2 g of selenium catalyst. Subsequently, 15 mL of concentrated sulfuric acid (H_2SO_4) was added to the mixture, which was then heated in a Kjeldahl flask at 360 °C for approximately 2 h to digest the organic matter. After digestion, the solution was allowed to cool and was transferred to a distillation unit. During the distillation step, 25 mL of 40% sodium hydroxide (NaOH) solution was added to convert ammonium sulphate into ammonia gas (NH_3), which was then liberated. The released NH_3 was captured in boric acid solution and subsequently titrated with 0.1 N hydrochloric acid (HCl) solution until a colour change was observed. The volume of titrant used was recorded and used to calculate the nitrogen (N) content of the sample. The determined nitrogen content was multiplied by a protein conversion factor (6.25) to obtain crude protein content.

Crude fat: Crude fat was determined using the Soxhlet extraction method. Two (2) g of finely ground dried mushroom sample were placed in the thimble of a Soxhlet apparatus. The sample was extracted for 6–8 h using 50 mL of hexane as the extraction solvent. The system was heated, allowing the solvent to evaporate, condense, and repeatedly pass through the sample to dissolve the fat content.

Once the extraction process was completed, the solvent was removed using a water bath. The extraction flask containing the fat residue was dried in an oven at 105 °C for 30 min to eliminate any residual solvent. After drying, the flask was cooled in a desiccator and weighed repeatedly until a constant weight was obtained. The crude fat content was calculated using Eq. (1).

$$\text{Crude Fat } (\%) = \frac{\text{Weight of fat extracted (g)}}{\text{Weight of sample (g)}} \text{ x } 100 \quad (1)$$

Where: Weight of fat extracted = Final weight of the extraction flask (after drying) – Initial weight of the flask

Crude fibre: The crude fibre content of mushroom samples was determined according to the AOAC crude fibre determination methods. A sequential acid and alkali digestion was conducted, followed by drying and ashing. Dried and finely ground mushroom samples (2 g) were digested with 1.25% sulfuric acid (H_2SO_4) and 1.25% sodium hydroxide (NaOH), each for 30 min, with washing after each digestion step to remove residual reagents. The treated samples were then dried in an oven at 105 °C until a constant weight was obtained, after which they were ashed in a muffle furnace at 550 °C for 3 h. The crude fibre content was calculated by subtracting the ash weight from the dried residue weight (Eq. 2).

$$\text{Crude Fiber } (\%) = \frac{\text{Weight of dried residue (g)} - \text{Weight of Ash (g)}}{\text{Weight of sample (g)}} \text{x } 100 \quad (2)$$

Crude Ash: Crude ash content was determined by incinerating dried mushroom samples to remove organic matter, leaving only mineral residues. Dried and finely ground mushroom samples (2–5 g) were placed in pre-weighed crucibles. The samples were first charred over a low flame to remove volatile substances and then incinerated in a muffle furnace at 550 °C for 4–6 h until white or grey ash was obtained. The crucibles were cooled in a desiccator and weighed to determine the ash content. The ash weight was calculated as the difference between the final weight of the crucible containing ash and the initial weight of the empty crucible using Eq. (3).

$$\text{Crude Ash} = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \text{ x } 100 \quad (3)$$

Where: Weight of ash = $W_3 - W_1$, Weight of sample = $W_2 - W_1$, and the total carbohydrate content was calculated using the difference from the total mass, accounting for moisture, protein, fat, and ash content.

Data statistical analysis

The collected nutritional data were analysed using descriptive statistics based on triplicate measurements ($n = 3$) for each mushroom species sample. Independent sample t-tests were conducted to assess the statistical significance of differences in nutrient composition between wild and cultivated mushrooms, as well as between fresh and dried samples (results presented in Supplementary Materials S1-S4). The impacts of processing (drying) on nutrient retention were determined through regression analysis, where a 95% confidence interval was used to identify key variables influencing nutrient preservation and the nutritional value of mushrooms (Figure S2). Data analysis was performed using Microsoft Excel.

Results and discussions

Mushroom identifications

A total of seven edible mushroom species were identified in this study, including five wild species and two cultivated varieties (Fig. 1). Species identification was conducted using a combination of macroscopic morphological observation, habitat documentation, and expert verification. Macroscopic morphological features, including cap shape,

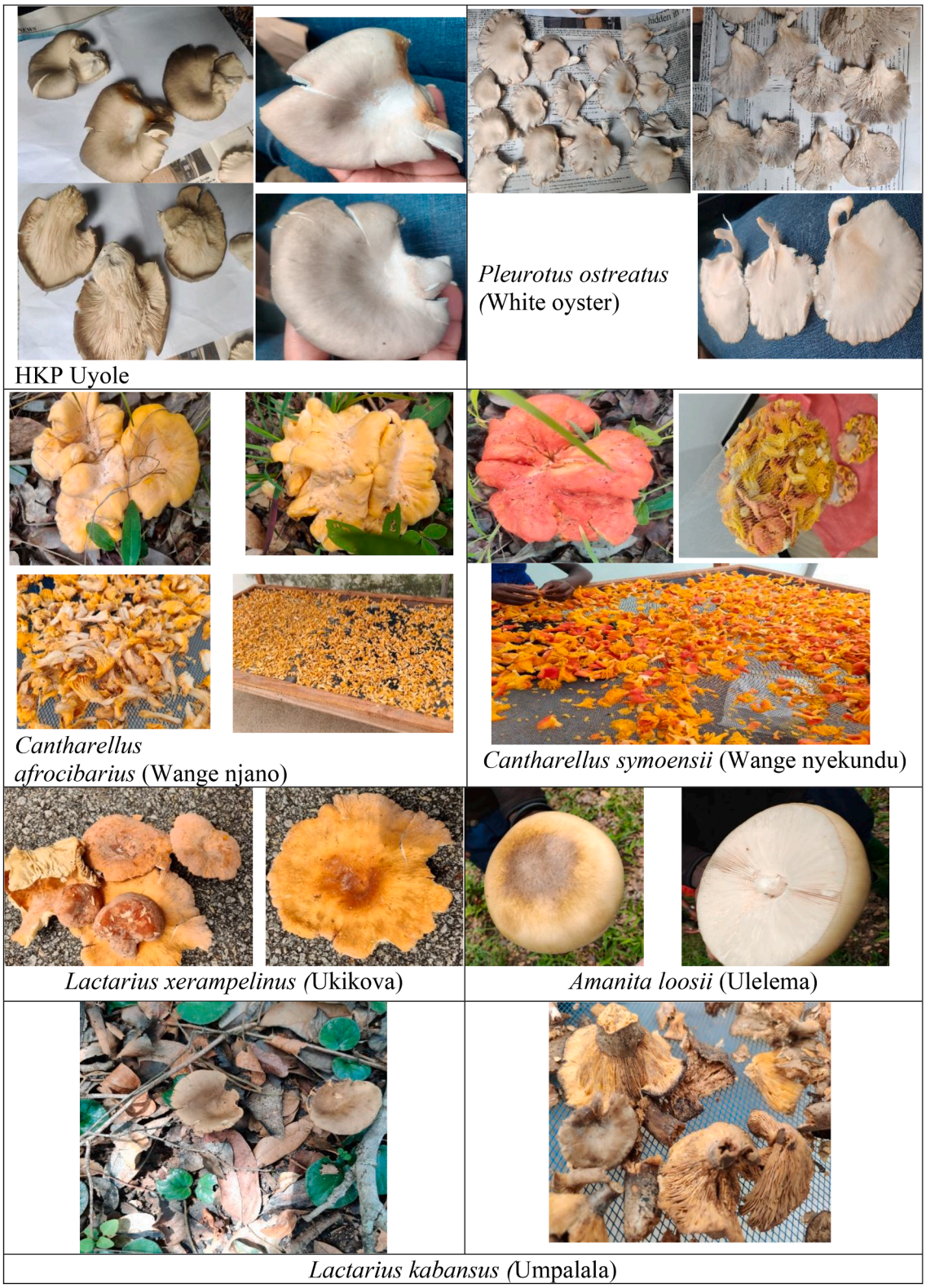

Fig. 1. Mushroom species, wild and cultivated, were studied in this study.

colour, and size; gill attachment and colour; stem structure; presence of volva or ring were recorded in the field using standard mycological identification keys and the reference *Wild Edible Mushrooms of Western Tanzania* by Härkönen et al. (2003)). Additionally, phenological characteristics, including season of occurrence, habitat type (miombo woodland, farmland, forest edges), and substrate (soil, deadwood, termite mounds) were documented to improve identification accuracy. Species identities were further confirmed by two regional mycologists with expertise in fungal taxonomy, ensuring reliability and scientific validity. Representative images of the identified mushroom species analysed in this study are presented in Fig. 1.

Moisture content

Moisture content is one of the most important factors when evaluating the nutritional value of mushrooms. In this study, the moisture content of both wild edible and cultivated mushroom species exceeded 88%. Cultivated mushroom species exhibited moisture content ranging from 88 to 90%, whereas all five wild edible species recorded moisture content of 90% or higher (Table 1). High moisture content in food strongly influences its quality, shelf life, nutritional properties, and susceptibility to microbial growth. The studied mushroom species, whether wild or cultivated, exhibited a very short shelf life at ambient temperatures, unless preserved through methods such as refrigeration or drying (Barros et al., 2008; Jamil et al., 2017) This shelf life observation is consistent with the high moisture levels recorded in this study, particularly in wild mushrooms,which often exceed 90% and promote rapid microbial growth and post-harvest deterioration (Kaygusuz et al., 2017; Kıvrak et al., 2020; Mleczek et al., 2015, 2022). Consequently, drying becomes an essential preservation method, playing a dual role in extending shelf life while simultaneously concentrating nutrients (Nakalembe et al., 2015a, 2015b; Zhang et al., 2020).

Nutritional analysis in selected mushrooms

A comparative analysis of the nutritional value was conducted to determine the proximate composition (crude protein, crude fat, crude fibre, ash, and carbohydrate) of studied species (Table S2, Fig. 2). All values are expressed on a dry matter basis (g/100g DM); however, moisture content is reported separately on a fresh weight basis (g/100g FW).

Crude protein

The protein content of both wild edible and cultivated mushroom species varied depending on species characteristics, physical attributes and the chemical composition of the growing medium (Manzi et al., 2001; Kalac, 2016). Among the wild edible mushroom species, *Lactarius kabansus* ("umpalala") exhibited higher protein content (38.6%), whereas Lactarius*xerampelinus* ("ukikova") showed the lowest protein content (31.3%) (Table S2 and Fig. 2). For cultivated species, protein content ranged from 28.06 to 29.36% (Fig. 3). Because the cultivated species analysed (Pleurotus ostreatus) differed from the wild mushroom species included in this study, direct species-to-species comparative analysis was not conducted. Instead, the nutritional composition of each species is presented individually on a dry matter basis. The relatively higher protein content observed in wild mushroom species may be attributed to their natural growth in diverse ecological environments such as miombo woodlands, where complex organic matter, decomposing plant residues, and symbiotic associations provide a wider range of nitrogen sources for fungal metabolism. In contrast, cultivated mushrooms are typically grown on controlled agricultural substrates such as straw or sawdust, which may contain more limited nitrogen availability, potentially influencing protein synthesis. These findings are consistent with previous studies reporting that wild mushrooms often exhibit higher protein concentrations than cultivated varieties due to ecological variability and nutrient-rich forest substrates (Jedidi et al., 2017). Additionally, mushrooms are widely recognised as a valuable source of dietary protein compared with many plant-based foods, making them an important alternative protein source for improving dietary diversity and addressing protein-energy malnutrition (Bauer Petrovska, 2001; Miles & Chang, 2004; Kalac, 2016).

Crude fat content

The average fat content in wild mushroom species ranged from 1.51% to 3.55%, with the highest fat content observed in *Cantharellus symoensii* ("wange nyekundu") and the lowest in *Lactarius xerampelinus* ("ukikova") (Table S2, Fig. 4). These findings are consistent with previous studies indicating that mushrooms typically contain low lipid concentrations relative to many plant-based foods (Kalač, 2016; Chang & Miles, 2004). Fat content in cultivated species ranged from 1.64% to 2.14%, which were not appreciably different from that of the wild species, a trend also reported by Melinda (2017) and Roman. This relatively low fat content indicates that mushrooms can serve as a nutritious food option for individuals seeking to reduce their dietary fat intake while benefiting from their other nutritional components. However, the differences in fat content between wild and cultivated species were not significantly different ($P > 0.05$) (Table S2).

Crude fibre, total ash content, and carbohydrate

The crude fibre, total ash content, and carbohydrate content differed significantly ($P < 0.05$) among wild and cultivated mushroom species. Among the wild species, the highest crude fibre content was recorded in *Amanita loosei* ("ulelema") (17.64%), whereas the lowest was observed in *Cantharellus symoensii* ("wange nyekundu") (10.71%). In contrast, the crude fibre content of cultivated mushrooms ranged 5.7% to 5.93% (Table 1; Fig. 3). The relatively higher fibre content observed in wild

Table 1
Proximate composition of mushroom species studied (data are expressed as % dry weight except for moisture content).

Cultivated mushrooms						
Mushroom species	Moisture (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Total ash (%)	Carbohydrates (%)
HKP Uyole (Fresh)	90.00 ± 0.00^{a}	29.36 ± 0.01^{b}	1.64 ± 0.00^{a}	5.70 ± 0.00^{b}	7.00 ± 0.03^{b}	56.30 ± 0.00^{a}
White Oyster (Fresh)	88.20 ± 0.00^{a}	28.06 ± 0.00^{b}	2.14 ± 0.10^{a}	5.93 ± 0.02^{b}	8.31 ± 0.10^{b}	55.56 ± 0.020^{a}
HKP Uyole (Dried)	13.70 ± 0.00^{b}	29.16 ± 0.20^{a}	1.99 ± 0.01^{a}	4.57 ± 0.01^{b}	6.41 ± 0.02^{b}	57.87 ± 0.00^{a}
White Oyster (Dried)	15.70 ± 0.00^{b}	28.81 ± 0.00^{a}	3.81 ± 0.10^{a}	4.65 ± 0.00^{b}	9.24 ± 0.00^{b}	53.50 ± 0.010^{a}
Wild mushroom species						
Mushroom species	Moisture (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Total ash (%)	Carbohydrates (%)
Ukikova (Fresh)	91.55 ± 1.34^{a}	31.30 ± 1.28^{a}	1.52 ± 0.35^{a}	15.85 ± 5.26^{a}	8.72 ± 0.50^{a}	42.62 ± 4.14^{b}
Ulelema (Fresh)	90.81 ± 0.43^{a}	38.00 ± 0.78^{a}	1.64 ± 0.37^{a}	17.64 ± 0.71^{a}	8.90 ± 0.04^{a}	33.82 ± 1.82^{b}
Umpalala (Fresh)	91.55 ± 2.90^{a}	38.60 ± 0.75^{a}	1.51 ± 0.37^{a}	16.41 ± 0.40^{a}	14.10 ± 0.14^{a}	29.38 ± 0.65^{b}
Wange Njano (Fresh)	90.44 ± 1.18^{a}	35.34 ± 0.41^{a}	3.15 ± 0.10^{a}	10.83 ± 0.84^{a}	11.55 ± 0.64^{a}	39.15 ± 1.80^{b}
Wange Nyekundu (Fresh)	91.93 ± 0.04^{a}	33.02 ± 1.22^{a}	3.56 ± 0.16^{a}	10.72 ± 0.98^{a}	9.46 ± 0.39^{a}	43.27 ± 0.01^{b}
Ukikova (Dried)	15.62 ± 0.47^{b}	28.88 ± 0.25^{b}	1.73 ± 0.30^{a}	12.12 ± 1.38^{b}	11.54 ± 0.58^{b}	45.75 ± 1.90^{a}
Ulelema (Dried)	15.62 ± 0.47^{b}	28.88 ± 0.25^{b}	1.73 ± 0.30^{a}	12.12 ± 1.38^{b}	11.54 ± 0.58^{b}	45.75 ± 1.90^{a}
Umpalala (Dried)	13.93 ± 5.35^{b}	28.84 ± 0.56^{b}	4.65 ± 0.77^{a}	8.75 ± 0.54^{b}	11.56 ± 0.01^{b}	46.21 ± 0.76^{a}
Wange Njano (Dried)	22.53 ± 0.47^{b}	25.16 ± 0.18^{b}	2.65 ± 0.40^{a}	9.39 ± 0.84^{b}	14.04 ± 1.16^{b}	48.77 ± 0.52^{a}
Wange Nyekundu (Dried)	11.83 ± 0.12^{b}	23.67 ± 0.18^{b}	3.40 ± 0.52^{a}	9.12 ± 0.08^{b}	12.36 ± 0.89^{b}	51.46 ± 1.31^{a}

Note: Values are presented as mean ± SD. Moisture content is expressed on a fresh weight basis, while other parameters are expressed on a dry weight basis. Within each nutrient column, mean values with ***different superscript letters (a, b)****differ significantly ($P < 0.05$) based on independent-sample* t*-tests. Comparisons performed between* ***fresh and dried wild mushrooms****, and between* ***fresh wild and fresh cultivated mushrooms****. Mean values sharing the same letter are not significantly different ($P \geq 0.05$).*

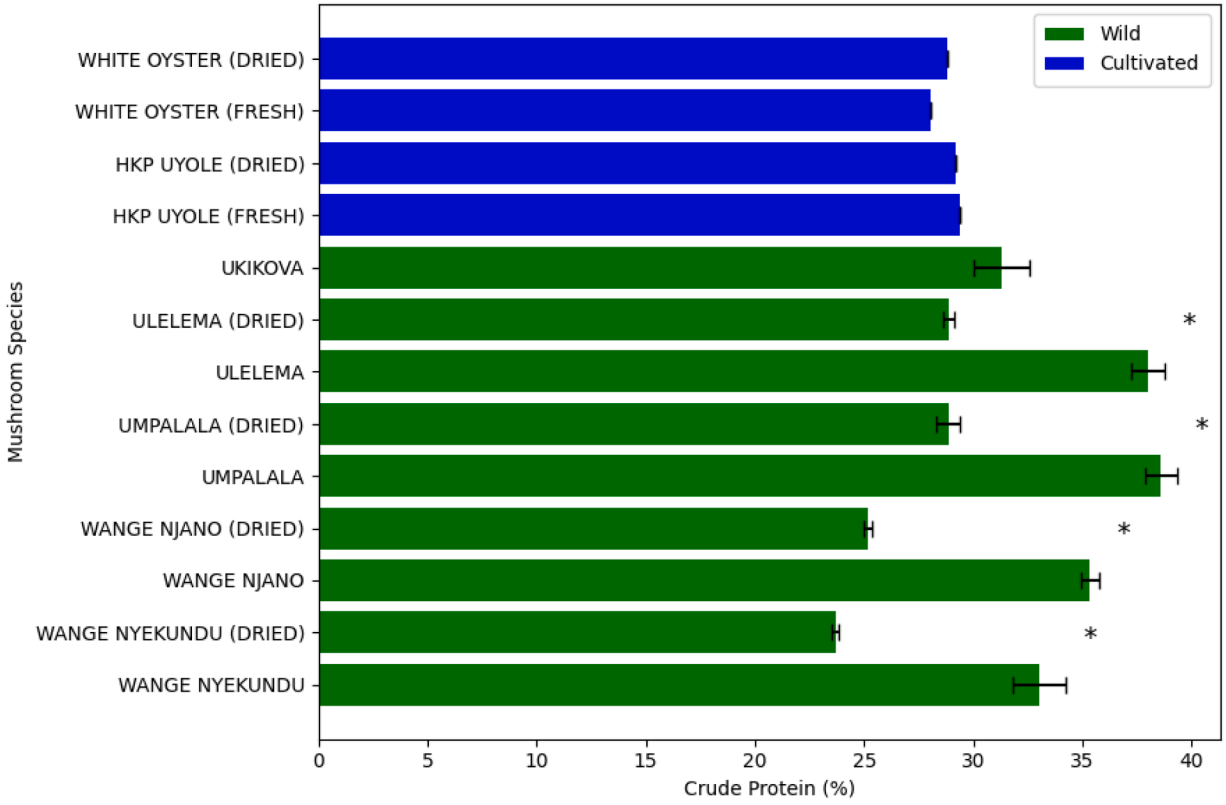

Fig. 2. Crude protein content (%) of studied mushroom species presented as mean ± standard deviation (SD). Wild mushroom species are shown in green and cultivated species in blue. Asterisks (*) indicate significant differences between fresh and dried samples ($P < 0.05$).

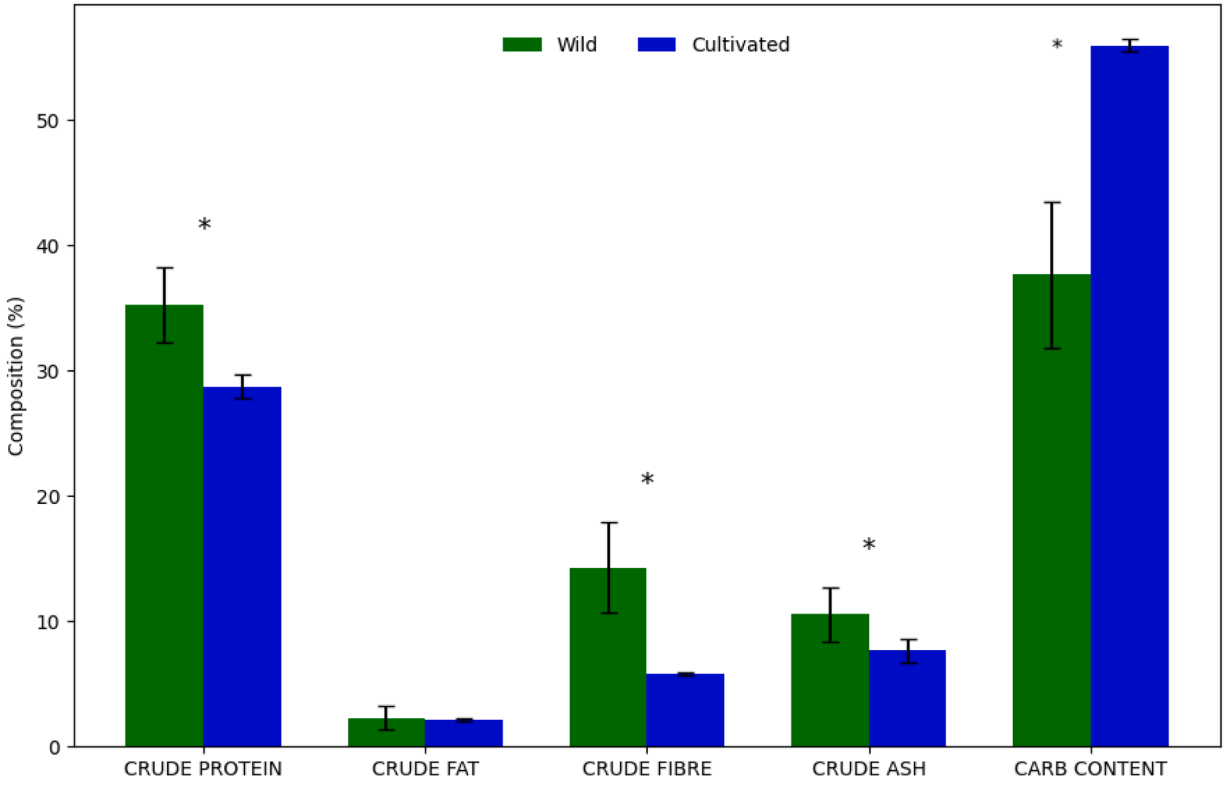

Fig. 3. Comparative nutritional analysis of edible wild and cultivated mushroom species, asterisks represent significant differences at $P < 0.05$.

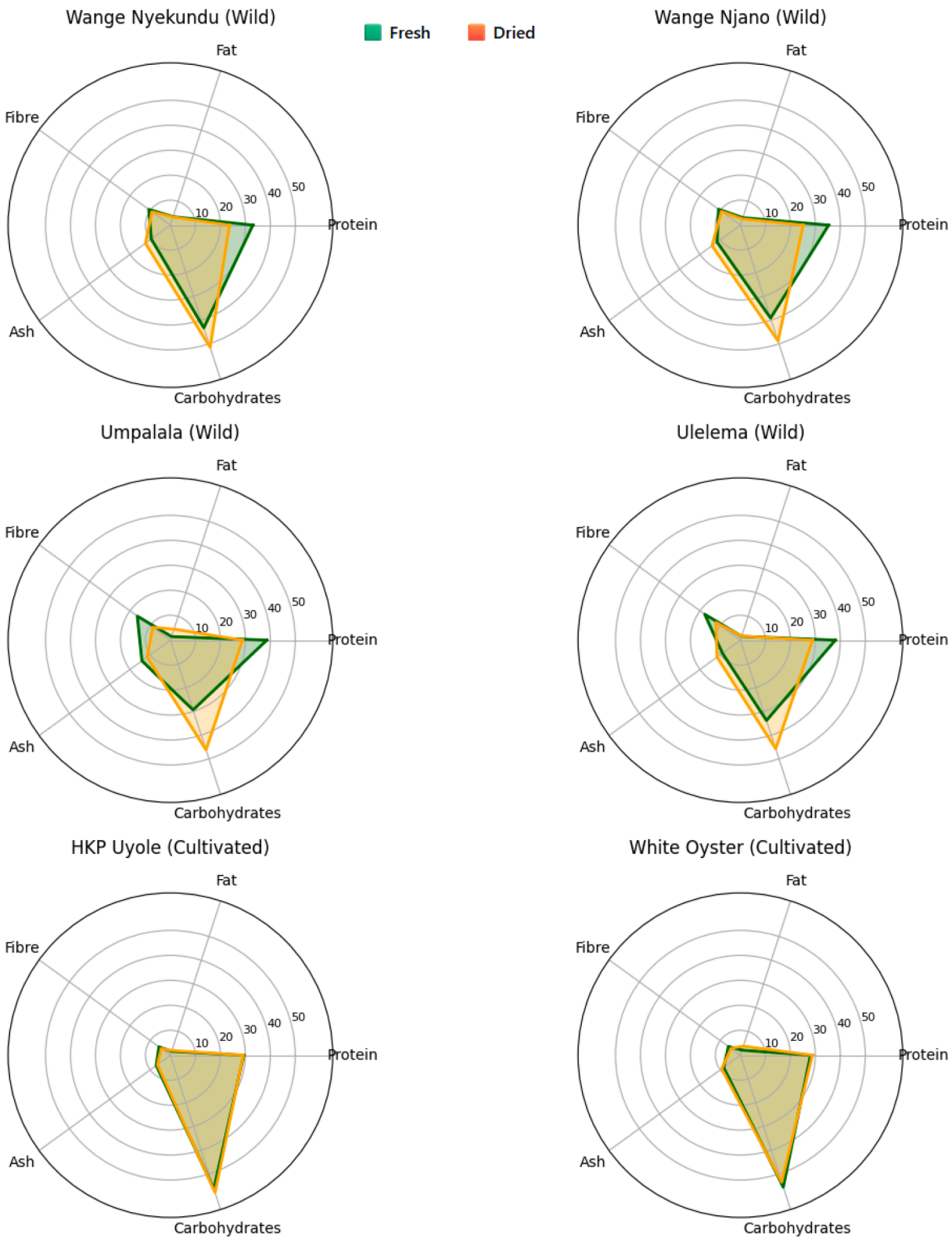

Fig. 4. Nutritional content comparison between fresh and dried mushroom species.

mushroom species may be attributed to their natural growth environments and diverse substrates, which influence fungal cell wall composition and structural polysaccharide accumulation. Crude fibre in mushrooms consists mainly of indigestible components such as cellulose, lignin, and other related polysaccharides, which support digestive health and gastrointestinal function (). Total ash content also varied significantly among the species ($P = 0.0035$), indicating notable differences in mineral composition between the wild and cultivated mushrooms. Ash content is commonly used as an indicator of total mineral concentration, suggesting that some wild species may provide higher levels of essential minerals.

Total carbohydrate content was observed to be higher in cultivated

mushrooms (55.81%), compared to wild mushrooms (42.88%) (Fig. 3). This difference may be related to the substrate composition used in mushroom cultivation, which can influence fungal carbohydrate accumulation during growth. Among the five selected wild mushroom species, *Lactarius kabansus* ("umpalala") stood out as nutritionally superior due to its relatively higher protein, fibre, and mineral contents, highlighting its potential importance as a nutrient-rich wild food resource. Overall, the results demonstrate considerable nutritional variability among mushroom species, highlighting the potential of wild edible mushrooms as valuable sources of protein, dietary fibre, and essential minerals.

These differences suggest that wild mushrooms may contribute more dietary fibre and minerals, whereas cultivated mushrooms may provide relatively higher carbohydrate content.

Impact of mushroom processing on nutritional quality

Drying is the most widely used mushroom preservation method in Tanzania, enabling off-season availability and reducing post-harvest losses. Previous studies indicate that more than 58% of farmers consume wild edible mushrooms in dried form, with sun drying being the dominant practice (Mamiro, 2010). In this study, the effects of drying on nutritional quality were assessed by comparing fresh and dried samples of four wild and two cultivated mushroom species (Fig. 4). Moisture content differed markedly between fresh and dried mushrooms. Fresh samples contained 88.20–91.55% moisture, whereas dried samples ranged from 11.83–15.70%, confirming the effectiveness of drying in reducing moisture content.

High moisture levels in fresh mushrooms contribute to rapid spoilage and reduced shelf life, while lower moisture content in dried mushrooms enhances microbial safety and storage stability (Mujumdar, 2006). Solar drying of wild mushrooms for 48 h resulted in moisture contents of 11.83–22.53%, comparable to cultivated mushrooms dried at 40 °C for 24 h (13.7–15.7%), with no marked differences observed between drying methods ($P = 0.54$) (Table S2). Although the drying conditions differed, these results suggest that solar drying can achieve moisture levels similar to those obtained under controlled drying conditions when sufficient drying time is applied. Protein content declined following drying. Fresh mushrooms recorded protein levels of 31.30 to 38.60%, while dried samples ranged from 23.62–29.16%, reflecting a statistically significant reduction ($P = 0.0049$; Cohen's d = 1.97). This decrease is likely due to heat-induced protein denaturation and oxidative reactions occurring during the drying process (Mujumdar, 2006). In contrast, fat, crude fibre, total ash, and carbohydrate contents showed no substantial differences between fresh and dried samples (Tables S2–S4). Average fat content was 2.16% (fresh) and 3.04% (dried), while carbohydrate content averaged 43.35% and 50.94%, respectively. Thus, drying effectively extends shelf life while largely preserving nutritional quality, supporting its continued use for enhancing food security and year-round mushroom availability (Nadew et al., 2024).

Shelf-life of selected mushroom species

This study assessed the shelf life of selected wild edible mushroom species under ambient laboratory conditions. Fresh samples were placed at room temperature and monitored for visible spoilage indicators, including moisture release, sliminess, and texture changes. Samples were discarded once these spoilage characteristics were observed. These samples were distinct from those stored under refrigeration for nutritional analysis. Marked variation in shelf life was observed among species. *Lactarius xerampelinus* ("Ukikova") remained fresh for up to four days, *Cantharellus afrocibarius* ("Wange njano") for three to four days, *Cantharellus symoensii* ("Wange nyekundu") for three days, and *Lactarius kabansus* ("Umpalala") for one day (Fig. 5). *Amanita loosei* ("Ulelema") showed the shortest shelf life, showing visible spoilage within 4 h. These findings highlight the highly perishable nature of wild mushrooms, largely due to their high moisture content, which accelerates microbial growth and enzymatic degradation (Mujumdar, 2006). Consequently, effective post-harvest preservation methods, particularly drying, are essential for reducing post-harvest losses and improving year-round mushroom availability and food security.

Nutritional potential, preservation, and market implications

Overall, the findings of this study highlight both the nutritional potential and the post-harvest challenges associated with wild edible

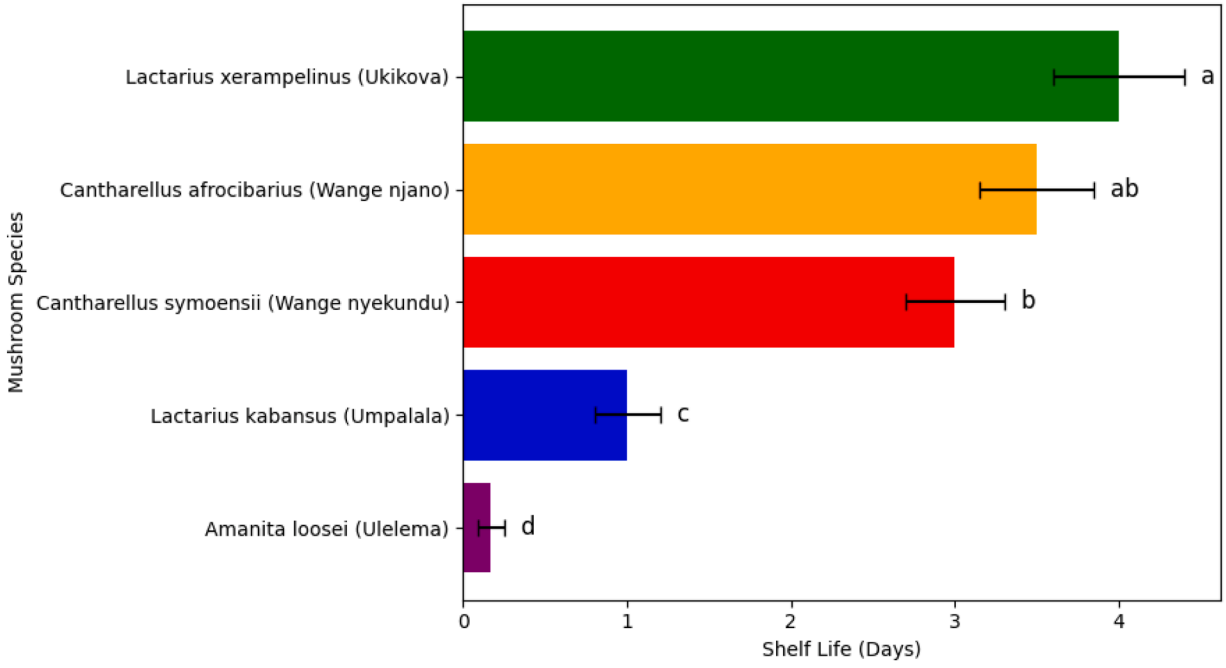

Fig. 5. Shelf life of edible wild mushroom species stored under ambient conditions. Bars with different letters indicate significant differences among species ($P < 0.05$).

mushrooms. The results demonstrate that wild mushroom species analysed possess high levels of protein, fibre, and ash content, comparable to or exceeding those of cultivated oyster mushrooms. This indicates that wild mushrooms represent valuable dietary resources with considerable potential for improving food and nutritional security. However, despite their nutritional richness, wild mushrooms remain underrepresented in commercial markets due to limited systematic promotion, inconsistent identification, and seasonal availability constraints (Chelela et al., 2015; Mdachi et al., 2004; Nteziryayo et al., 2019; Tibuhwa, 2013). In addition, the short shelf life observed in several species further emphasizes the need for effective post-harvest preservation strategies. Developing standard processing, packaging, and branding strategies for wild mushrooms could improve market integration, enhance household nutrition, and generate income opportunities for rural collectors, while ensuring food safety standards are maintained.

Conclusion and recommendation

The present study demonstrates that wild edible mushrooms are nutrient-dense foods with strong potential to enhance dietary diversification and food security in Tanzania. Compared with cultivated varieties, wild species showed higher protein, fibre, mineral, and carbohydrate contents, indicating nutritional advantages despite limited statistical differentiation. Drying is confirmed as a critical post-harvest preservation method, extending shelf life while largely maintaining nutritional quality. To fully realize this potential, improvements in harvest practices, preservation, accurate species identification, and market-oriented branding are needed to integrate wild mushrooms into formal food systems. Policy support should focus on safe commercialization, community-based processing initiatives, and training on species identification. Future research should investigate micronutrients, bioactive compounds, economic feasibility, and standardized drying methods to strengthen the role of wild mushrooms in sustainable food systems.

Study limitations

This study focused on proximate composition under ambient storage conditions and did not analyse micronutrients, bioactive compounds, or controlled post-harvest handling environments.

Data availability

All datasets used and analysed during the current study and supporting information are available from the corresponding authors on request.

Funding

The present study was supported by ADAP (Association for the Development of Protected Areas).

Consent to participate

Were obtained to all participating parties during the study.

Consent for publication

Not Applicable.

Code availability

Not Applicable.

CRediT authorship contribution statement

Anna Minja Arturu: Writing – review & editing, Writing – original draft, Visualization, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marco E. Mng'ong'o:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors wish to thank all laboratory technicians and technical staff at Mbeya University of Science and Technology for technical support during lab work, and ADAP (Association for the Development of Protected Areas) for financial support.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.focha.2026.101274.

References

Official methods of analysis of AOAC International (18th ed.). (2005). Gaithersburg, MD: AOAC International.

Adedokun, O. M., Odiketa, J. K., Okieroho, O. E., & Afieroho, M. C. (2022). Importance of mushrooms for food security in Africa. *Food Security in Africa: Bridging Research and Practice*, 343–360. https://doi.org/10.1007/978-981-16-6771-8_20

Balan, V., Munafo, J. P., Jr, Pattathil, S., Merritt, B. B., & Venketachalam, S. (2018). Protocols to evaluate the nutritional and potential health benefits of edible mushrooms. *Current Biotechnology, 7*(1), 34–58. https://doi.org/10.2174/2211550105666160503170750

Barroetaveña, C., & Toledo, C. V. (2016). The nutritional benefits of mushrooms. In I. C. F. R. Ferreira, P. Morales, & L. Barros (Eds.), *Wild plants, mushrooms and nuts: Functional food properties and applications*. Chichester, UK: John Wiley & Sons. https://doi.org/10.1002/9781118944653.ch3.

Barros, L., Venturini, B. A., Baptista, P., Estevinho, L. M., & Ferreira, I. C. F. R. (2008). Chemical composition and biological properties of portuguese wild mushrooms: A comprehensive study. *Journal of Agricultural and Food Chemistry, 56*(10), 3856–3862. https://doi.org/10.1021/jf8003114

Bauer Petrovska, B. (2001). Protein fraction in edible Macedonian mushrooms. *European Food Research and Technology, 212*(4), 469–472. https://doi.org/10.1007/s002170000285

Bloesch, U.. *Wild edible mushrooms from Western Tanzania.*Adansonia-Consulting. https://www.adansonia-consulting.ch/mushrooms.php.

Chelela, B., Chacha, M., & Matemu, A. (2014). Wild edible mushroom value chain for improved livelihoods in Southern Highlands of Tanzania. http://dspace.nm-aist.ac.tz/handle/20.500.12479/2079.

Chelela, B., Chacha, M., & Matemu, A. (2015). Wild mushrooms from Tanzania: Characterization and their importance to the rural communities. http://dspace.nm-aist.ac.tz/handle/20.500.12479/1435.

Härkönen, M., Niemelä, T., & Mwasumbi, L. (2003). Tanzanian Mushrooms: *Edible, Harmful, and Other Fungi.* ISBN (Hardback): 952-10-1420-2.

Hussein, J. M., Tibuhwa, D. D., Mshandete, A. M., & Kivaisi, A. K. (2015). Antioxidant properties of seven wild edible mushrooms from Tanzania. *African Journal of Food Science, 9*(9), 471–479. https://academicjournals.org/journal/AJFS/article-full-text/6F7531D55449.

Idrees, M., Yaqoob, S., Leo, S. F., Khan, A. A., Sun, L., Yang, Y., Li, D., Fu, Y., & Li, Y. (2019). A Comparison of the physical, chemical, and structural properties of wild and commercial strains of button mushroom, *Agaricus bisporus* (Agaricomycetes). *International Journal of Medicinal Mushrooms, 21*(6), 611–625. https://doi.org/10.1615/IntJMedMushrooms.2019030681

Jamil, N. A. M., Rashid, N. M. N., Hamid, M. H. A., Rahmad, N., & Al-Obaidi, J. R. (2017). Comparative nutritional and mycochemical contents, biological activities and LC/MS screening of tuber from new recipe cultivation technique with wild type tuber of tiger's milk mushroom of species Lignosus rhinocerus. *World Journal of Microbiology & Biotechnology, 34*(1), 1. https://doi.org/10.1007/s11274-017-2385-4

Jedidi, I. K., Ayoub, I. K., Philippe, T., & Bouzouita, N. (2017). Chemical composition and nutritional value of three Tunisian wild edible mushrooms. *Journal of Food*

Measurement and Characterisation, 11(4), 2069–2075. https://doi.org/10.1007/s11694-017-9590-6

Juma, I., Mshandete, A. M., Tibuhwa, D. D., & Kivaisi, A. (2016). Assessment of antioxidant potentials of the wild and domesticated saprophytic edible mushrooms from Tanzania. *Current Research in Environmental & Applied Mycology, 6*(2016), 1–10. https://www.researchgate.net/profile/Anthony-Mshandete/publication/291334513_Assessment_of_antioxidant_potentials_of_the_wild_and_domesticated_saprophytic_edible_mushrooms_from_Tanzania_Article/links/56a004b908ae2c638eb7d7ea/Assessment-of-antioxidant-potentials-of-the-wild-and-domesticated-saprophytic-edible-mushrooms-from-Tanzania-Article.pdf.

Kalac, P. (2016). *Edible mushrooms: chemical composition and nutritional value*. Academic Press.

Kaygusuz, O., Kaygusuz, M., Dodurga, Y., Seçme, M., Herken, E. N., & Gezer, K. (2017). Assessment of the antimicrobial, antioxidant and cytotoxic activities of the wild edible mushroom Agaricus lanipes (F.H. Møller & Jul. Schäff.) Hlaváček. *Cytotechnology, 69*(1), 135–144. https://doi.org/10.1007/s10616-016-0045-4

Kivaisi, A. K. (2007). Mushroom cultivation in Tanzania–a new industry. *Opera Mycologia, 1*, 12–22.

Mamiro, D. P., Mamiro, P. S., Msemwa, J., & Mpangala, B. (2010). Survey of indigenous knowledge on gathering, processing, and use of edible wild mushrooms for household food security and income generation in Masasi, Tanzania. *Tanzania Journal of Forestry and Nature Conservation, 80*(2).

Manzi, P., Aguzzi, A., & Pizzoferrato, L. (2001). Nutritional value of mushrooms widely consumed in Italy. *Food Chemistry*.

Mdachi, S. J., Nkunya, M. H., Nyigo, V. A., & Urasa, I. T. (2004). Amino acid composition of some Tanzanian wild mushrooms. *Food Chemistry, 86*(2), 179–182. https://www.sciencedirect.com/science/article/pii/S0308814603004369.

Melinda, N., Socaci, S., Tofană, M., Biriș-Dorhoi, E.-S., Țibulcă, D., Salanță, L., & Petruț, G. (2017). Chemical composition and bioactive compounds of some wild edible mushrooms. *Bulletin UASVM Food Science and Technology, 74*(1). https://doi.org/10.15835/buasvmcn-fst:12629

Miles, P. G., & Chang, S. T. (2004). *Mushrooms: cultivation, nutritional value, medicinal effect, and environmental impact*. CRC press.

Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC) [Tanzania Mainland], Ministry of Health (MoH) [Zanzibar], Tanzania Food and Nutrition Centre (TFNC), National Bureau of Statistics (NBS), Office of the Chief Government Statistician (OCGS) [Zanzibar] and UNICEF. 2018. Tanzania National Nutrition Survey using SMART Methodology (TNNS) 2018. Dar es Salaam, Tanzania: MoHCDGEC, MoH, TFNC, NBS, OCGS, and UNICEF.2. WFP, 2024, Annual country report. https://www.wfp.org/operations/annual-country-report?operation_id=TZ02&year=2024#/33626/336303.

Mleczek, M., Siwulski, M., Mikołajczak, P., Gąsecka, M., Sobieralski, K., Szymańczyk, M., & Goliński, P. (2015). Content of selected elements in Boletus badius fruiting bodies growing in extremely polluted wastes. *Journal of Environmental Science and Health. Part A, Toxic/Hazardous Substances & Environmental Engineering, 50*(7), 767–775. https://doi.org/10.1080/10934529.2015.1012014

Mleczek, M., Budka, A., Siwulski, M., Budzyńska, S., Kalač, P., Karolewski, Z., Lisiak-Zielińska, M., Kuczyńska-Kippen, N., & Niedzielski, P. (2022). Anthropogenic contamination leads to changes in mineral composition of soil- and tree-growing mushroom species: A case study of urban vs. rural environments and dietary implications. *The Science of the Total Environment, 809*, Article 151162. https://doi.org/10.1016/j.scitotenv.2021.151162

Kıvrak, I., Kivrak, S., & Karababa, E. (2020). Assessment of bioactive compounds and antioxidant activity of Turkey tail medicinal mushroom trametes versicolor (Agaricomycetes). *International Journal of Medicinal Mushrooms, 22*(6), 559–571. https://doi.org/10.1615/IntJMedMushrooms.2020035027

Mshandete, A. M., & Cuff, J. (2007). Proximate and nutrient composition of three types of indigenous edible wild mushrooms grown in Tanzania and their utilization prospects. *African Journal of Food, Agriculture, Nutrition and Development, 7*(6). https://www.ajol.info/index.php/ajfand/article/view/136197.

Mujumdar, A. S. (2006). *Handbook of Industrial Drying*. CRC Press.

Mwita, L. N., Lyantagaye, S. L., & Mshandete, A. M. (2011). Cultivation of Tanzanian Coprinus cinereus (sisal compost mushroom) on three non-composted sisal waste substrates supplemented with chicken manure at various rates. *International Journal of Biological and Chemical Sciences, 5*(3).

Nadew, T. T., Reshad, A. S., & Tedla, T. S. (2024). Oyster mushroom drying in a tray dryer: Parameter optimization using response surface methodology, drying kinetics, and characterization. *Heliyon*.

Nakalembe, I., Kabasa, J. D., Olila, D., & Muyanja, C. (2015b). Comparative nutrient composition of selected wild edible mushrooms from Uganda. *Food Science & Nutrition, 3*(6), 433–440.

Nakalembe, I., Kabasa, J. D., & Olila, D. (2015a). Comparative nutrient composition of selected wild edible mushrooms from two agro-ecological zones, Uganda. *SpringerPlus, 4*(1), 433. https://doi.org/10.1186/s40064-015-1188-z

Nteziryayo, V., Tibuhwa, D., Kiyuku, P., Muvunyi, R., & Masharabu, T. (2019). Characterization and domestication of wild edible mushrooms from selected indigenous forests in Burundi. *Tanzania Journal of Science, 45*(3), 417–430. https://www.ajol.info/index.php/tjs/article/view/191719.

Rai, R. D., & Arumuganathan, T. (2008). *Post-harvest technology of mushrooms*. Chambaghat: National Research Centre for Mushroom (Indian Council of Agricultural Research). Solan-173 213 (HP.

Ratti, C. (2001). Hot air and freeze-drying of high-value foods: A review. *Journal of Food Engineering, 49*(4), 311–319.

Rikolto. (2024). Good Food for Cities. https://eastafrica.rikolto.org/programmes/good-food-for-cities.

Tibuhwa, D. D. (2013). Wild mushroom- an underutilized healthy food resource and income generator: Experience from Tanzania rural areas. *Journal of Ethnobiology and Ethnomedicine, 9*(1), 49. https://doi.org/10.1186/1746-4269-9-49

Watling, R., Frankland, J. C., Ainsworth, A. M., & Isaac. (2002). In C. H. Robinson (Ed.), *Tropical mycology: 1 – Macromycetes*. Wallingford, UK: CABI Publishing.

WFP, 2024, Annual country report. https://www.wfp.org/operations/annual-country-report?operation_id=TZ02&year=2024#/33626/33630.

Yuliana, N. D., Saraswati, H., Regiyana, Y., Nora, A., Hutabarat, D. J. C., & Lioe, H. N. (2024). Advances in metabolomics to optimize quality parameters of culinary mushrooms. *Trends in Food Science & Technology, 145*, Article 104378. https://doi.org/10.1016/j.tifs.2024.104378

Zhang, J., Barałkiewicz, D., Hanć, A., Falandysz, J., & Wang, Y. (2020). Contents and health risk assessment of elements in three edible ectomycorrhizal fungi (Boletaceae) from polymetallic soils in Yunnan Province, SW China. *Biological Trace Element Research, 195*(1), 250–259. https://doi.org/10.1007/s12011-019-01843-y