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EFFECT OF COOKING ON THE PROXIMATE COMPOSITION AND MINERALS CONTENT OF WILD EDIBLE MACRO FUNGI FROM LORE LINDU NATIONAL PARK, CENTRAL SULAWESI, INDONESIA

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ABSTRACT

Lore Lindu National Park was the most important flora and fauna protected area in Central Sulawesi, Indonesia. This area has high biodiversity, one of which is edible macro fungi. Macro fungi have attracted worldwide attention and reputation because of their diverse functions including beauty and aesthetics, medicinal effects (anticancer, antidiabetic, immunoenhancing and antioxidant), cosmetic ingredients, high nutritional value as food, economic value and ecosystem services. Macro fungi were rich in essential minerals, micro elements, vitamins, protein, carbohydrates and fiber. Indigenous peoples around this area have long been using edible macro fungi that grow wild in the forest both as a source of food and medicine. This study aimed to analyze the effect of cooking on the proximate composition and mineral content of several edible macro fungi originating from the Lore Lindu National Park area (*Auricularia* sp*, Auricularia auricula-judae, Termitomyces* sp*, Lentinus* sp*, Pleurotus ostreatus, Schizophyllum commune, Agaricus sp, Boletus* sp). Determination of the nutritional composition of edible macro fungi was carried out by mineral analysis using the AAS (Atomic absorption spectrophotometry) method and proximate analysis. Differences in proximate and mineral composition between cooked and uncooked edible macro fungi samples were analyzed by T-test. The results showed that all tested samples contained substantial amounts of nutrients and essential proteins. Cooked and uncooked edible macro fungi contain significant macro and micro minerals (Ca, Mg, P, K, S, Cu, Mn, Fe and Zn). The amount of protein and dietary fiber in edible macro fungi was also significantly affected by the cooking process. The fiber content in edible macro fungi increases when cooked, while the composition of carbohydrates, protein, fat, ash content and some mineral elements decreases due to cooking. This research shows that cooked and uncooked edible macro fungi have potential nutritional principles. The evaluation of the nutritional components (protein, fiber, carbohydrates, minerals, amino acids, unsaturated fatty acids and IVPD (in-vitro protein digestibility) and the calorific value of edible macro fungi indicated a low-fat and low-calorie diet, which was lower than legumes and meat.

Key words: Macro fungi, nutrition, proximat, minerals, Lore Lindu National Park

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INTRODUCTION

Macro fungi including Phyllum Ascomycotina and Basidiomycotina generally form fruiting bodies [1]. There are more than 2,000 species of macro fungi in nature, but only about 25 species are accepted as food sources and very few have been cultivated commercially [2]. Macro fungi that grow wild in nature have a long historical relationship with humans because they play an important role in human life, and have a great impact from both biological and economic aspects [3]. Macro fungi have become one of the most important horticultural commodities in developed countries [4]. Macro fungi have attracted worldwide attention and reputation because of their diverse functions including beauty and aesthetics, medicinal effects (anticancer, antidiabetic, immunoenhancing and antioxidant), cosmetic ingredients, high nutritional value as food, economic value and ecosystem services [5,6,7,8,9,10]. The utilization of macro fungi as a source of nutrition to replace animal food products is an alternative to meet human dependence on animal protein. This is especially the case in developing countries, where good quality protein from animal sources is unavailable or unacceptable due to religious beliefs [11,12].

In terms of nutrition, macro fungi are rich in essential minerals, micro elements, vitamins, protein, carbohydrates and fiber [4,13,14,15,16,17,18,19]. Protein, essential amino acids, fiber, minerals, fatty acids, vitamins found in edible macro fungi are indispensable as a source of nutrition and human health [20,21]. The nutritional content of edible macro fungi is strongly influenced by several factors, namely the substrate where they grow, fungi species, geographic area, harvest time, phase and body parts of edible macro fungi harvested as well as cultivation and processing technology by the community [18,22,23,24,25,26,27,28,29,30,31).

Bernaś *et al.* [32] reported that the chemical composition of edible macro fungi greatly determines their nutritional value and properties. Modern pharmacological research confirms that most of the traditional knowledge regarding the medicinal effects of macro fungi is due to their antifungal, antibacterial, antioxidant and antiviral properties [2,3,5,13]. On the other hand, wild edible macro fungi have not been well documented, under-studied and underutilized in many countries even though these macro fungi are a very potential non-timber forest product. There are no systematic surveys and studies on wild edible macro fungi harvesting, marketing and income potential from it [2]. Meanwhile, FAO has emphasized the use of macro fungi as an ideal food for developing countries and their contribution to global food security.

A survey of the diversity of macro fungi and their potential as food ingredients in the Lore Lindu National Park area, Central Sulawesi, Indonesia has been carried out. Based on the exploration results, nine types of macro fungi were found, namely *Schizophyllum commune*, *Termytomyces sp*, *Auricularia auricula-judae*, *Auricularia sp*., *Pleurotus ostreatus*, *Ganoderma lucidum*, *Xylaria sp*., *Agaricus sp*. and *Lentinus sajor-caju* which is used as a source of food and traditional medicine by local people, but its nutritional value is unknown [33]. This study aimed to determine the effect of cooking on the proximate and mineral composition of eight types of wild edible macro fungi (*Auricularia sp*, *Auricularia auricular-judae*, *Termitomyces sp*., *Lentinus sp*,

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Pleurotus ostreatus, *Schizophyllum commune*, *Agaricus sp*, *Boletus sp*) from the Lore Lindu National Park, Central Sulawesi, Indonesia.

MATERIAL AND METHODS

Collection of edible macro fungi in the field

Sample collection of wild edible macro fungi was carried out in Toro Village, Kulawi District, Sigi Regency, around Lore Lindu National Park, Central Sulawesi, Indonesia (14°50′–14°51′ N, 74°24′–74°27′ E). Wild edible macro fungi were collected from several types of land use based on local wisdom of indigenous peoples in Toro village, namely primary forest (Wana Ngkiki and Wana), secondary forest (Pangale), shrubs (Oma) and agroforestry land (Pampa). These edible macro fungi grow on litter as well as rotten wood trunks and twigs. After harvesting, the fruit bodies of edible macro fungi are cleaned by gently wiping with a dry tissue to remove any adhering dirt. Wild edible macro fungi samples were collected in a collection box and brought to the laboratory for identification. These edible macro fungi were identified based on the morphological characteristics of each type of fungus [34,35]. Coarse-textured edible macro fungi were preserved in 4% (v/v) formaldehyde and soft-textured mushrooms were preserved in 2% (v/v) formaldehyde. Furthermore, edibe macro fungi samples maintained as a specimen and stored in the Laboratory of Forestry Sciences, Faculty of Forestry, Tadulako University.

Treatment of edible macro fungi samples

The fresh edible macro fungi samples were divided into two parts, namely the first treatment, the fruit bodies of fresh edible macro fungi were dried using a drying oven (DSR115, Isuzu, Japan) (50–55°C) [9.18,23]. The second treatment was that the fruit bodies of edible macro fungi were cooked in a pressure cooker using distilled water followed by drying using a drying oven (50–55°C). After drying, the edible macro fungi samples were ground into a fine powder. The dried powder samples of cooked and uncooked edible macro fungi were sieved using a 100 mesh sieve. The edible macro fungi samples were transferred to airtight plastic bottles, labeled and sealed in plastic bags to prevent water from entering and stored in a refrigerator at 4°C before analysis. Proximate and mineral analyzes were carried out on mushroom samples three times.

Proximate Analysis for Edible Macro Fungi

Moisture Content Analysis

The moisture content of the edible macro fungi flour samples was analyzed using the gravimetric method [36]. The aluminum cup was dried in an oven at 130ºC for 15 minutes, then cooled in a desiccator for 10 minutes. The dried cup was weighed before use. The edible macro fungi flour (2 g) sample was weighed into the cup, then dried in an oven at 130°C for 1 hour, cooled in a desiccator and weighed until the weight was constant. The moisture content is calculated by the following formula:

Moisture content (%) = (Loss in weight / fresh sample weight) x 100

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Ash Content Analysis

The ash content of edible macro fungi flour samples was analyzed using the gravimetric method [36,37]. Empty porcelain dishes and lids were dried in an oven at 105°C for 15 minutes and cooled in a desiccator. The dry porcelain dish was weighed and the weight recorded before use. The edible macro fungi flour (3-5 g) were weighed in the porcelain dish and put in an electric Muffle Furnace 79in³ (Model MF-1310) at 550°C, 24 hours until complete ashing. After ashing is complete, the sample crucible is cooled in a desiccator, then weighed. Weighing is repeated until a constant weight is obtained. Calculation of ash content is carried out using the following formula:

Ash content (%) = (ash weight / fresh sample weight) x 100

Total Fat Content Analysis

The fat content of edible macro fungi flour samples was analyzed using Soxhlet method [36]. The fat extraction flask was dried in an oven at 105°C for 15 minutes, cooled in a desiccator and weighed before used. The sample (1-2 g) was put into a filter paper sleeve which was lined with cotton. The paper sleeve containing the sample was plugged with cotton, then dried in an oven at a temperature of not more than 80°C for 1 hour. The paper sleeve was inserted into the Soxhlet apparatus which has been connected to the fat flask. The fat in the sample was extracted with hexane for 6 hours. Hexane was distilled to obtain a fat extract. The fat extract in the fat flask was then dried in an oven at 105°C for 12 hours, then cooled in a desiccator and weighed. Drying was repeated until a constant weight was obtained. Oven drying at a temperature of 105°C has the risk of causing the loss of volatile fatty acid content of the edible macro fungi samples. The fat content of edible macro fungi was calculated on dry weight using the following formula:

$$Fat\ content\ (\%) = \left(\frac{Weight\ fat\ extractied\ by\ soxhlet}{Sample\ weight}\right)\ X\ 100$$

Total Protein Content Analysis

Protein content of edible macro fungi flour samples was analyzed using the Kjeldahl method [36]. The sample (100-250 mg) was put into a Kjeldahl flask then added with 1.9 ± 0.1 g K_2SO_4, 40.0 ± 10 mg HgO, and 2.0 ± 0.1 mL concentrated H_2SO_4. The sample was heated with a gradual increase in temperature to boiling for 1-1.5 hours until a clear liquid is obtained. After cooling, the contents of the flask were transferred to a distillation flask by rinsing with 1-2.0 mL of distilled water 5-6 times. The washing water was transferred to a distillation flask and then added with 8-10 mL of a 60% NaOH - 5% $Na_2S_2O_3$ solution. In a separate container, 5.0 mL of H_3BO_3 solution and 2-4 drops of methyl-blue methyl red indicator were added to an erlenmeryer. The Erlenmeyer flask was then placed under the condenser with the tip of the condenser submerged under the H_3BO_3 solution. The distillation process was carried out until approximately 15.0 mL of distillate was obtained. The distillate obtained was diluted to 50.0 mL with distilled water, then titrated with standardized 0.02 N HCl solution until the color changed to gray. The volume of the standardized 0.02 N HCl solution used for the titration was recorded. The same step was carried out for the blank solution so that a

volume of 0.02N HCl solution was obtained for the blank. Protein content was calculated based on nitrogen content (%N). The protein content was calculated on a dry weight using a correction factor of 6.25 as follows:

$$Nitrogen\ content\ (\%) = \left(\frac{(v1 - v2)\ X\ N_{HCl}\ X\ 14.007}{W} \right)\ X\ 100$$

Notes :

v1= volume of HCl solution for sample (mL); v2=volume of HCl solution for blank (mL); NHCl= concentration of HCl solution (0,02N), w= sample weight (mg); Protein content (%) = % N x conversion factor (6,25)

Carbohydrate Content Analysis

The carbohydrate content of the edible macro fungi flour samples was calculated on dry weight as follows:

Carbohydrate content (% dry weight) = 100 – (% moisture + % ash + % fat + % protein)

Mineral Analysis for Edible Macro Fungi

The mineral content (nitrogen, sodium, potassium, calcium, sulfur, phosphorus, iron) of edible macro fungi flour samples was determined using atomic absorption spectrophotometry (GBC 932, Hampshire, IL, USA) [36,37]. Nitrogen (N) content needs to be analyzed with the Atomic Absorption Spectrophotometer (AAS) instrument for ensuring precisely the number of free N ionic elements that are not bound to amino acids, peptides, and proteins contained in edible macrofungi samples. The Kjeldahl method generally measures total N content, including N bound to amino acids, peptides, and proteins. The vanadomolybdophosphoric acid method was used to determine total phosphorus with KH_2PO_4 as standard.

Data analysis

The data from the proximate and mineral analysis of each edible macro fungi were expressed as the mean ± standard deviation (SD) for three replications. Significant differences (T-value < 0.05) in the results of proximate and mineral analysis between cooked and uncooked edible macro fungi samples were analyzed using T-test (Statistic version 8: Stat Soft Inc. 2008).

RESULTS AND DISCUSSION

Proximate Composition of Edible Macro Fungi

The proximate composition of 8 samples of wild edible macro fungi (Figure 1) (*Auricularia* sp., *Auricularia auricula-judae, Boletus* sp., *Termytomyces* sp., *Pleurotus ostreatus, Schizophyllum commune*, *Agaricus* sp., *Lentinus* sp.) were carried out in this study with cooked and uncooked treatments (Table 1). Cooked and uncooked treatments had a significant effect on the moisture, ash, protein, fat, fiber and carbohydrate content of the 8 samples of the edible macro fungi. The cooking treatment

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had a significant impact ($p<0.05$) on the decrease in total protein content in edible macro fungi (Table 1). During the cooking process using a pressure cooker using distilled water, denaturation occurs so that coagulation occurs and decreases its solubility. Cooking treatment until it reaches a temperature of 70-80^{o}C causes the protein contained in edible macro fungi to denature and change shape. This condition can cause the protein source food to shrink and lose moisture. Denatured protein will precipitate because the groups are positively and negatively charged in the same amount or are neutral or in an isoelectric point state. In denaturation, hydrogen bonds are broken, hydrophobic interactions and salt bonds occur until the protein molecules do not have folds anymore. Denatured protein cannot be returned to its original form (irreversible).

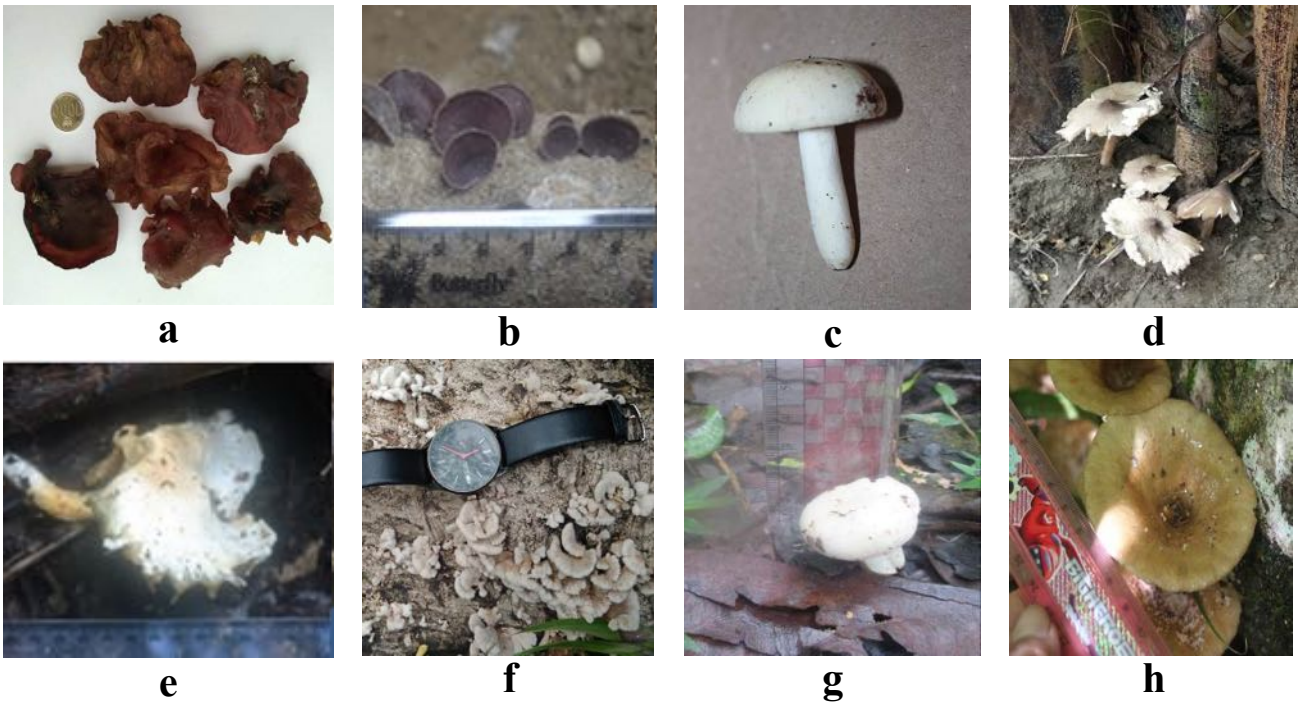

Figure 1: The types of wild edible macro fungi collected from Lore Lindu National Park (a=*Auricularia auricula-judae, b= Auricularia sp, c=Boletus sp, d=Termytomices sp, e=Pleurotus sp, f=Schizophyllum commune, g=Agaricus sp, h=Lentinus sp)*

Cooking treatment with distillated water was proven to have a significant effect ($p<0.05$) on reducing the ash content of edible macro fungi (Table 1). The ash content in food shows the presence of mineral elements as inorganic compounds that act as cofactors for enzymes and micronutrients. The decrease in ash content due to cooking indicates the loss of most of the edible macro fungi minerals which will dissolve along with the distilled water. Cooking treatment also had a significant effect on reducing total fat content in edible macro fungi. High temperature heating and pressure during cooking can damage the fat structure contained in edible macro fungi.

The increase in dietary fiber content in 8 samples of edible macro fungi (*Auricularia* sp., *Auricularia auricula-judae, Boletus* sp., *Termytomyces* sp., *Pleurotus ostreatus,*

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Schizophyllum commune, *Agaricus* sp., *Lentinus* sp.) due to ripening occurs due to the retrogradation process. During cooking, the starch components that make up edible macro fungi would be gelatinized and then retrograded to form resistant starch which was identified as dietary fiber. Dietary fiber was a nutritional component that can be eaten but cannot be digested by enzymes in the human digestive tract. Dietary fiber also mostly acts as a prebiotic because it can only be digested into simpler products and used as a source of nutrition by probiotic bacteria found in the colon. There are 2 types of fiber based on their solubility in water, namely insoluble fiber and water soluble fiber. Insoluble fiber is part of the tough plant cell walls, namely cellulose, hemicellulose, lignin and resistant starch, which are part of water insoluble fiber [4]. Insoluble fiber can be obtained from foods made from whole wheat, fruit skins, cucumbers, tomatoes, rice husks (usually brown rice), legumes, and beans [32]. Soluble fiber was not part of plant cell walls, for example, arabinoxylans (AX), -glucans, some hemicelluloses, pectins, gums and inulin [38].

The proximate composition showed that fiber and protein were the highest followed by ash and fat in cooked and uncooked edible macro fungi samples. The results showed variations in the nutritional and proximate content of each edible macro fungi, both cooked and uncooked. The cooking process by boiling edible macro fungi samples to a boiling point can reduce the levels of several nutrients including protein compared to samples of legume seeds such as mung bean (*Phaseolus aureus*), pigeon pea (*Cajanus cajan*), chickpea (*Cicer arietinum*) and long bean (*Vigna radiata* and *V. unguiculata*) [4,12,17] . The protein content of edible macro fungi was on average lower, while the fiber content and ash content are higher than the content in the fungus Termitomyces robustus [39]. Protein was an important component of the dry matter of edible macro fungi. Protein compounds are more than half of the total nitrogen, and their content depends on the composition of the substratum, pileus size, harvest time and type of fungus [32]. The main compounds of edible macro fungi were proteins and carbohydrates. The protein content of edible macro fungi was reported to be influenced by several factors, namely the type of fungus, stage of development, part of the sample, available nitrogen content and location [40]. Yield and nutritional content of edible macro fungi were influenced by the type, cultivation conditions including the chemical composition of the substrate where it grows [41,42,43].

There was a very significant increase in proximate content between the cooked and uncooked edible macro fungi samples, where the average was lower in the cooked mushroom samples. According to a report by Okoro and Achuba [9] that the protein, fiber and ash content of mushroom samples were higher than those of *Agaricus* sp. Based on a more detailed analysis of edible macro fungi samples, Cheung [44] stated that the greater amount and unique composition of fiber could be considered as important for human nutrition and health. However, low fiber content can be used as a basis for correcting protein and carbohydrate deficiencies [45]. On the other hand, high fiber can provide health benefits, especially lowering blood cholesterol and lowering the risks of colon cancer [46]. The carbohydrate and calorie content of *A. abruptibulbus* and *T. globulus* species is higher than that of edible macro fungi that grow wild in nature [38]. The high carbohydrate content of edible macro fungi has been studied to treat colon cancer, including the low glycemic content that can prevent type II diabetes.

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Mineral Contents of Edible Macro Fungi

The eight samples of edible macro fungi contained various macro and micro minerals as follows: N, P, K, Ca, Na, S, Fe. Among these minerals, the Nitrogen and Potassium content was the highest followed by Sodium, Sulfur, Phosphorus and Calcium in cooked and uncooked edible macro fungi samples (Table 2). The results also showed that the macro mineral potassium composition was higher than other minerals in all types of edible macro fungi analyzed (Table 2). The edible macro fungi contain minerals that are present in the substrate on which they grow, including potassium and large amounts of Ca and Fe [18].

Potassium was a positively charged ion and is found in cells and intracellular fluids. Potassium plays a role in maintaining fluid and electrolyte balance as well as acid and base balance along with sodium [47]. Together with calcium, potassium plays a role in nerve transmission and muscle contraction. In cells, potassium functions as a catalyst in many biological reactions, especially energy metabolism and glycogen and protein synthesis and plays a role in cell growth. Potassium was easily absorbed in the small intestine. Potassium was excreted through urine, feces, sweat and gastric juices. Normal blood potassium levels were maintained by the kidneys through their ability to filter, reabsorb and excrete potassium under the influence of aldosterone. Potassium was excreted in the form of ions by replacing sodium ions through an exchange mechanism in the renal tubules [47].

Sodium was the main cation in the extracellular fluid (35-40%) found in the skeleton, bile and pancreas [48]. Sodium plays a role in maintaining fluid balance in the extracellular compartment, regulating osmotic pressure which keeps fluid from leaving the blood and entering cells, maintaining acid-base balance in the body by balancing substances that form acid, playing a role in nerve transmission and muscle contraction, playing a role in glucose absorption and as a means of transporting other nutrients through membranes, especially through the intestinal wall as a sodium pump. Sodium was actively absorbed in the small intestine (requires energy), then carried by the bloodstream to the kidneys to be filtered and then returned to the bloodstream in sufficient quantities to maintain sodium levels in the blood. Excess sodium would be excreted through the urine which was regulated by the hormone aldosterone which was released by the adrenal glands if blood sodium levels decrease [48].

Phosphorus was the second most abundant mineral in the body, accounting for about 1% of body weight. Phosphorus was found in bones and teeth as well as in cells, namely muscles and extracellular fluid [49]. Phosphorus was part of the nucleic acids DNA (Deoxyribonucleic Acid) and RNA (Ribonucleic Acid). As a phospholipid, phosphorus is a structural component of cell walls. As an organic phosphate, phosphorus plays a role in reactions related to the storage or release of energy in the form of Adenosine Triphosphate (ATP). Phosphorus plays a role in regulating energy transfer in carbohydrate, protein and fat metabolism through the phosphorylation process of phosphorus by activating various enzymes and B vitamins. Phosphorus plays a role in the absorption and transportation of nutrients, buffer systems, and regulates

acid-base balance. Phosphorus can be efficiently absorbed as free phosphorus in the intestine after being hydrolyzed and released from the diet by the enzyme alkaline phosphatase in the small intestinal mucosa and is actively absorbed assisted by the active form of vitamin D and passive diffusion. Phosphorus levels in the blood are regulated by parathyroid hormone (PTH) released by the parathyroid glands and calcitonin hormone and vitamin D, to control the amount of phosphorus absorbed, the amount retained by the kidneys, the amount released and stored in the bones. Parathyroid hormone (PTH) decreases the reabsorption of phosphorus by the kidneys. Calcitonin increases the excretion of phosphorus by the kidneys [26].

Calcium is the most abundant mineral in bones and teeth. In the extracellular and intracellular fluids, calcium plays an important role in regulating cell functions, such as nerve transmission, muscle contraction, blood clotting and maintaining cell membrane permeability [9]. Calcium regulates the work of hormones and growth factors. As much as 30-50% of calcium consumed was absorbed by the body which occurs in the upper part of the small intestine, namely the duodenum [48]. Calcium requires a pH of 6 to exist in a dissolved state. Calcium absorption was mainly carried out actively using a protein-binding calcium transporter. Passive absorption occurs on the surface of the gastrointestinal tract. Calcium can only be absorbed if it is present in a water-soluble form and does not precipitate due to other food elements [49]. Calcium that is not absorbed was excreted in the feces. Loss of calcium can occur through urine, secretions of fluids that enter the gastrointestinal tract and sweat [9].

Sulfur comes from food which was bound to sulfur-containing amino acids which are necessary for the synthesis of essential substances [38]. Moreover, sulfur is plays a role in oxidation-reduction reactions, part of thiamine, biotin and insulin hormones and helps detoxify [39]. Furthermore, sulfur also plays a role in dissolving metabolic waste to be excreted through the urine in oxidized form association with mucopolysaccharides [39]. Sulfur was absorbed as part of amino acids or as inorganic sulfate. Sulfur was also part of the enzyme glutathione as well as various coenzymes and vitamins, including coenzyme A [40]. The most of sulfur was excreted in the urine as free ions. Sulfur was also one of the intracellular electrolytes found in low concentrations of plasma [50].

Iron was an important component of proteins involved in oxygen transport in humans. It was also important for the regulation of cell growth and differentiation. Iron deficiency limits oxygen delivery to cells, resulting in fatigue, poor performance, and decreased immunity [41]. On the other hand, excess amounts of iron can cause poisoning and even death [26]. Nearly two-thirds of the iron in the body is found in hemoglobin, the protein in red blood cells that carries oxygen to tissues [38]. Smaller amounts of iron were found in myoglobin, a protein that helps supply oxygen to muscles, and in enzymes that aid in biochemical reactions [48]. Iron was also found in proteins that store iron for future needs and transport iron in the blood [39]. Iron storage was regulated by intestinal absorption of iron. There are two forms of iron namely heme and nonheme. Heme iron in hemoglobin is a micromineral compound that binds with protein in red blood cells that delivers oxygen to cells. Heme iron was found in animal foods that initially contain hemoglobin, such as red meat, fish, and poultry [47]. The iron in plant foods such as lentils and beans is arranged in a chemical

structure called nonheme iron. This was a form of iron that is added to iron-fortified foods. Heme iron absorbs nutrition better than nonheme iron. However, most iron in edible macro fungi is categorized as nonheme iron [47]. Iron absorption refers to the amount of iron the body gets and uses from food. Healthy adults absorb about 10% to 15% of iron, but individual absorption was affected by several factors [47]. The level of iron storage has the greatest influence on iron absorption. Absorption of iron increases when its availability in the body is low. When iron availability is high, absorption decreases to help protect against the toxic effects of iron overload [47].

CONCLUSION

The evaluation of the nutritional components (protein, fiber, carbohydrates, minerals, amino acids, unsaturated fatty acids, and the calorific value) of edible macro fungi indicated a low-fat and low-calorie diet, which was lower value than legumes and meat. Since the protein content (in-vitro protein digestibility) is higher in cooked edible macro fungi, raw/undercooked/cooked edible macro fungi may be used depending on the nutritional requirements of the particular product. Cooking has a significant effect in increasing the fiber content of food, but reduces the content of ash, protein, fat, carbohydrates and some mineral components contained in edible macro fungi. Evaluation of nutritional components (protein, fiber, carbohydrates, minerals, and fat) in edible macro fungi significantly shows a lower value than legumes and meat. The edible macro fungi are recommended as alternative functional food ingredients, especially for people with diabetes mellitus and obesity, because of high protein and fiber content but low fat.

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Authors' contributions

YY, EE, HM, AK designed and conducted field research; YY, EE, HM and AK performed laboratory analysis; YY and RHBS wrote the manuscript with inputs from all co-authors; RHBS had final responsibility for content. All authors read and approved the final manuscript.
[YY- Yusran Yusran; EE- Erniwati Erniwati; HM- Haerani Maksum; AK- Akhmad Khumaidi; RHBS- R. Haryo Bimo Setiarto]
(All authors contributed equally to this manuscript)

Conflict of Interest

There is no conflict of interest between the authors in the research and writing of this manuscript.

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Table 1: Proximate composition of eight types of wild edible macro fungi collected from Lore Lindu National Park

Types of Macro Fungi	Parameter	Treatment	
		Uncooked	Cooked
Auricularia sp.	Moisture content (%)	10.84 ± 0.06	11.66 ± 0.17
	Protein (%)	11.14 ± 0.01	9.33 ± 0.15*
	Fiber (%)	21.96 ± 0.02	32.53 ± 0.29*
	Ash (%)	3.39 ± 0.04	3.69 ± 0.19
	Fat (%)	1.58 ± 0.01	1.32 ± 0.05
	Carbohydrate (%)	51.09 ± 0.41	41.47 ± 0.33*
Auricularia auricula-judae	Moisture content (%)	43.54 ± 1.33	31.36 ± 0.39*
	Protein (%)	5.80 ± 0.10	6.93 ± 0.03
	Fiber (%)	18.61 ± 0.28	21.17 ± 0.12*
	Ash (%)	1.44 ± 0.05	2.12 ± 0.05
	Fat (%)	0.73 ± 0.03	0.63 ± 0.06
	Carbohydrate (%)	29.88 ± 0.61	37.79 ± 0.32*
Boletus sp.	Moisture content (%)	9.50 ± 0.40	6.85 ± 0.17*
	Protein (%)	11.43 ± 0.01	9.33 ± 0.15*
	Fiber (%)	4.03 ± 0.06	5.19 ± 0.10*
	Ash (%)	4.54 ± 0.14	4.77 ± 0.18
	Fat (%)	1.68 ± 0.10	1.37 ± 0.15
	Carbohydrate (%)	68.82 ± 0.88	72.49 ± 0.71*
Termytomyces sp.	Moisture content (%)	19.81 ± 0.20	15.78 ± 0.08*
	Protein (%)	30.73 ± 0.32	21.91 ± 0.02*
	Fiber (%)	5.87 ± 0.10	7.20 ± 0.10*
	Ash (%)	12.49 ± 0.26	8.79 ± 0.10*
	Fat (%)	2.95 ± 0.02	0.62 ± 0.04*
	Carbohydrate (%)	28.15 ± 0.31	45.70 ± 0.22*
Pleurotus ostreatus	Moisture content (%)	17.88 ± 0.04	10.95 ± 0.03*
	Protein (%)	23.54 ± 0.34	21.42 ± 0.19*
	Fiber (%)	6.72 ± 0.05	11.36 ± 0.02*
	Ash (%)	5.70 ± 0.05	2.42 ± 0.01*
	Fat (%)	1.51 ± 0.04	2.13 ± 0.02
	Carbohydrate (%)	44.65 ± 0.42	51.72 ± 0.62*
Schizophyllum commune	Moisture content (%)	10.18 ± 0.03	10.01 ± 0.01
	Protein (%)	23.72 ± 0.15	23.84 ± 0.22
	Fiber (%)	2.10 ± 0.10	2.45 ± 0.29
	Ash (%)	7.06 ± 0.04	6.91 ± 0.04
		1.04 ± 0.02	2.14 ± 0.06

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	Fat (%) Carbohydrate (%)	55.90 ± 0.82	54.65 ± 0.33
Agaricus sp.	Moisture content (%) Protein (%) Fiber (%) Ash (%) Fat (%) Carbohydrate (%)	11.95 ± 0.05 22.54 ± 0.64 36.11 ± 0.09 16.81 ± 0.08 1.34 ± 0.03 11.25 ± 0.65	10.05 ± 0.02 27.61 ± 0.40* 42.93 ± 0.06* 12.41 ± 0.10* 1.59 ± 0.02 5.41 ± 0.21*
Lentinus sp.	Moisture content (%) Protein (%) Fiber (%) Ash (%) Fat (%) Carbohydrate (%)	10.15 ± 0.03 27.03 ± 0.05 9.01 ± 0.05 6.21 ± 0.02 1.26 ± 0.08 46.34 ± 0.33	9.52 ± 0.04 25.16 ± 0.02* 11.02 ± 0.01* 7.08 ± 0.01 1.01 ± 0.01 46.21 ± 0.41

*(T-value < 0.05 = Significant different)

Table 2: Mineral content of eight types of wild edible macro fungi collected from Lore Lindu National Park

Types of Macro Fungi	Parameter	Treatment	
		Uncooked	Cooked
Auricularia sp.	N (%) P (%) K (%) Ca (%) Na (%) S (%) Fe (%)	1.78 ± 0.04 0.056 ± 0.05 0.82 ± 0.015 Not detected 0.87 ± 0.02 0.11 ± 0.015 0.16 ± 0.005	1.48 ± 0.01* 0.053 ± 0.05 0.83 ± 0.011 Not detected 0.32 ± 0.03 0.18 ± 0.05 * 0.12 ± 0.032*
Auricularia auricula-judae.	N (%) P (%) K (%) Ca (%) Na (%) S (%) Fe (%)	0.93 ± 0.03 0.02 ± 0.015 0.116 ± 0.03 0.006 ± 0.002 0.26 ± 0.115 0.08 ± 0.01 0.17 ± 0.03	1.11 ± 0.01* 0.02 ± 0.005 0.110 ± 0.01 0.013 ± 0.005 0.12 ± 0.053* 0.15 ± 0.02 * 0.28 ± 0.01 *
Boletus sp.	N (%) P (%) K (%) Ca (%) Na (%) S (%) Fe (%)	2.48 ± 0.09 0.16 ± 0.01 0.82 ± 0.015 Not detected 0.87 ± 0.015 0.11 ± 0.015 0.28 ± 0.02	2.76 ± 0.01* 0.13 ± 0.03 0.83 ± 0.011 Not detected 0.32 ± 0.032* 0.18 ± 0.005 * 0.16 ± 0.01 *
Termytomyces sp.	N (%)	4.92 ± 0.025	0.30 ± 0.015*

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	P (%)	0.36 ± 0.02	0.30 ± 0.01 *
	K (%)	2.81 ± 0.02	2.72 ± 0.01 *
	Ca (%)	Not detected	Not detected
	Na (%)	0.28 ± 0.01	0.23 ± 0.005*
	S (%)	0.26 ± 0.015	0.33 ± 0.01 *
	Fe (%)	1.63 ± 0.06	0.17 ± 0.03 *
Pleurotus ostreatus	N (%)	3.76 ± 0.11	3.43 ± 0.04*
	P (%)	0.19 ± 0.03	0.24 ± 0.03
	K (%)	1.25 ± 0.27	1.71 ± 0.03 *
	Ca (%)	Not detected	Not detected
	Na (%)	0.42 ± 0.23	0.01 ± 0.005*
	S (%)	0.26 ± 0.03	0.23 ± 0.02
	Fe (%)	0.16 ± 0.004	0.16 ± 0.03
Schizophyllum commune	N (%)	3.78 ± 0.10	3.81 ± 0.13
	P (%)	0.19 ± 0.03	0.20 ± 0.01
	K (%)	1.120 ± 0.14	1.123 ± 0.04
	Ca (%)	Not detected	Not detected
	Na (%)	0.55 ± 0.10	0.36 ± 0.02*
	S (%)	0.28 ± 0.005	0.17 ± 0.025 *
	Fe (%)	0.36 ± 0.03	0.41 ± 0.03
Agaricus sp.	N (%)	4.48 ± 0.76	4.42 ± 0.13
	P (%)	0.26 ± 0.17	0.23 ± 0.03
	K (%)	2.37 ± 0.76	1.76 ± 0.01
	Ca (%)	Not detected	Not detected
	Na (%)	0.25 ± 0.04	0.68 ± 0.02*
	S (%)	0.26 ± 0.01	0.27 ± 0.05
	Fe (%)	0.84 ± 0.04	0.76 ± 0.03 *
Lentinus sp.	N (%)	4.32 ± 0.13	4.03 ± 0.02*
	P (%)	0.16 ± 0.02	0.14 ± 0.02
	K (%)	0.91 ± 0.02	0.73 ± 0.03 *
	Ca (%)	Not detected	Not detected
	Na (%)	0.87 ± 0.02	0.96 ± 0.02*
	S (%)	0.27 ± 0.01	0.21 ± 0.01 *
	Fe (%)	0.78 ± 0.03	0.70 ± 0.02 *

*(T-value < 0.05 = Significant different)

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