

Effect of the Coconut Coir (*Cocos nucifera*) as a Growth Medium for *Pleurotus ostreatus* (Oyster Mushroom) on Mineral and Vitamin B Contents

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ABSTRACT

The oyster mushroom (*Pleurotus ostreatus*) is the most cultivated mushroom which its growth performance and nutritional composition depend on substrate types. Thus, this study investigated the effect of coconut coir on minerals and vitamins B contents in the oyster mushroom cultivation medium. The composition of coconut coir and Sengon's sawdust as growth medium were varied at ratios of 4:0 (F1), 3:1 (F2), 2:2 (F3), 1:3 (F4), 0:4 (F5) (w/w). Furthermore, the mineral and vitamin B contents of the harvested oyster mushrooms were analyzed by ICPMS and LCMS, respectively. The highest minerals contents of potassium 26,909 mg/kg, 1,136 mg/kg of phosphorus, 313 mg/kg of magnesium, 4,346 mg/kg of calcium, 15.4 mg/kg for zinc, 2.07 mg/kg of copper, 0.623 mg/kg of Selenium were identified at F1, whereas the highest manganese was at F2 (15.3 mg/kg). Potassium was the highest mineral content in oyster mushrooms in all growth media, and low toxic minerals content of cadmium was detected between 0.015-0.058 mg/kg in all variant substrates. Lead (0.525 mg/kg) and mercury (0.012 mg/kg) was only detected at F1, while arsenic was detected at F4 (0.002 mg/kg) and F5 (0.029 mg/kg). LCMS analysis showed that vitamin B1 (Thiamine), B3 (niacin), B6 (pyridoxine) and B12 (cyanocobalamin) were detected in all growth media, while vitamin B5 (pantothenic acid) was only detected at F5. These results indicated that the *P. ostreatus* cultivation on coconut coir become valuable nutritional resources to alleviate malnutrition and help dispose of coconut coir in an environment-friendly manner.

1. Introduction

Agricultural wastes are increasing due to agro-industrial development, and when mismanaged, they may pollute the air and water and endanger human health. These are composed of structural polymers such as cellulose, hemicellulose, and lignin that can be easily broken down by lignocellulosic enzymes through mushroom biodegradation, serving as an energy source for mycelial growth (Okano *et al.* 2007). Saprophytic mushroom cultivation of *Pleurotus* may be the only economically viable biotechnology for handling and recycling organic waste (Obodai *et al.* 2003).

In Indonesia, farmers of white oyster mushroom (*Pleurotus ostreatus*) typically use Sengon (*Paraserianthes falcataria*) sawdust as the primary substrate for *P. ostreatus* cultivation. However, mushroom cultivation, which heavily relies on sawdust, tends to reduce the area of wooded land. As a result, there has been an increase in forest protection awareness and proper management in utilizing the forest area for specific purposes in recent years (Liang *et al.* 2009). Thereby, interest in finding the alternative substrate or growth medium for sustainable cultivation of *P. ostreatus* is important.

Coconut coir is one of the most abundant in Indonesia, creating 1.8 million tons per year. It comprises approximately 26.72% cellulose, 17.73% hemicellulose, and 41.19% lignin, with high enough mineral content and can bind and store water

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strongly (Sangian *et al.* 2015). However, since the usage is currently limited, the simplest approach to converting coconut coir into healthy food is to utilize it as a growth medium of *P. ostreatus*.

The growth performance and nutritional composition in oyster mushrooms depend on medium types. It has been reported to be cultivated on various organic substrates such as cotton wastes, sugarcane bagasse, wheat straw, and rice straw (Khare *et al.* 2010). The composition of the medium is essential for the absorption and accumulation of minerals, including toxic elements, from the edible part of mushrooms (Siwulski *et al.* 2017). Mineral elements such as K, Na, Mg, Ca, Mn, Fe, Cu, Zn, and Co are involved in fungal growth, metabolism, and differentiation. However, toxic metals like Pb, Cd, and Hg can cause morphological abnormalities, reduce growth, increase mortality, and mutagen in humans (Moliszewska *et al.* 2015). *P. ostreatus* provides a nutritionally significant vitamin B1, B2, B12, C, D, and E (Matilla *et al.* 2001). It also contains folic acid (Nwoko *et al.* 2017), non-starchy carbohydrates, high content of dietary fiber, and a moderate quantity of proteins, including amino acids (Ahmed *et al.* 2013). Several scientific works have been conducted to determine the nutritional composition of *P. ostreatus* with different substrates. However, further study is required to investigate the micronutrients such as mineral elements and vitamin B contents of *P. ostreatus* cultivated in a growth medium with variation in coconut coir composition for substrates.

2. Materials and Methods

2.1. Materials

Coconut coir and Sengon sawdust were obtained from a local farmer in Surabaya, Indonesia. Meanwhile, ammonium acetate, KH_2PO_4 , H_3PO_4 ,

chalk powder (CaCO_3), gypsum (CaSO_4), and HNO_3 65% were purchased from SAP chemicals, Indonesia. Chloroform and acetonitrile were obtained from Anhui Fulltime Specialized Solvent and Reagent Co., Ltd (Anhui, China), while potato dextrose agar (PDA) were purchased from Merck Darmstadt, Germany).

2.2. Fungal Stock and Sengon Sawdust Spawn Preparation

Pleurotus ostreatus BM9073 stock cultures from a local farmer in Surabaya were grown on a 9-cm diameter PDA. At the same time, Sengon sawdust spawn was made in 850 ml bottles containing 500 g Sengon sawdust, supplemented with 1% bran and 0.5% CaCO_3 . The final mixture's water content was adjusted to 65 percent (w/w) and sterilized for 80 minutes at 121°C. After cooling to room temperature, sterilized Sengon sawdust was inoculated with 9 cm² of *P. ostreatus* mycelium from the PDA medium. The spawn was incubated at 25°C and 70% humidity for two weeks (Liang *et al.* 2009).

2.3. Preparation of the Growth Medium, Inoculation, and Incubation

The coconut coir was completely sun-dried as a medium and then powdered and sieved (40 mesh). Several materials and binding growth mediums were tested to determine suitable growth mediums and appropriate ratios for *P. ostreatus* growth (Table 1), which the growth medium was carried out with 3 repetitions. The control consists of ingredients calculated based on growth medium-dry weight (w/w), 70% Sengon sawdust, 15% rice bran, 5% corn flour, 5% CaCO_3 , 5%, and sugar adjusted 6 L (800 g sugar/L). The aggregate becomes stuffed into polyethylene bags (50 g) for every growth medium (backlog). After the backlogs were cooled to room temperature, it was inoculated with *P. ostreatus* of Sengon sawdust. The inoculated

Table 1. Variation in coconut coir composition for medium growth variation and time for stimulation to primordia initiation (Days)

Medium growth variation (% coconut coir (w/w)) ^a	Weight of Coconut coir (kg)	Weight of Sengon saw dust (kg)	Time for stimulation to primordia initiation (Days)
F1 (100%)	3.00	0.00	24±1.0 ^a
F2 (75%)	2.25	0.75	19±0.5 ^b
F3 (50%)	1.50	1.50	18±1.0 ^c
F4 (25%)	0.75	2.25	16±1.0 ^d
F5 (control)(0%)	0.00	3.00	9±2.0 ^e

^aAll substrates also contained 600 g rice bran, 200 g of chalk powder (CaCO_3), 200 g of gypsum (CaSO_4), 200 g of corn flour. Data are mean ± standard deviation (n = 5). Data followed by the same lower-case letter on time for stimulation to primordia initiation column are not significantly different (P < 0.05)

backlogs were stored in a spawning box at 25°C and a humidity of 70% in the dark. Furthermore, the number of days from inoculation to complete colonization of the growth medium by the mycelium was counted from spawning to complete colonization. The mycelium growth rate was defined as height (mm) in inoculated culture carved by incubation period (days).

2.4. Cropping

After sprouting, the backlogs were transported to a seeding chamber and kept at 28°C with 80 % relative humidity and 100 lux of lighting. The seed room was periodically watered to keep moisture at some stage in sowing (Liang *et al.* 2009).

2.5. Mineral Elements and Toxic Element Determinations by using ICP-MS

Dried powder of harvested *P. ostreatus* (0.5 g) was digested in concentrated HNO₃ 65 % in microwave digestion. Then it was quantified by Inductively Coupled Plasma Mass Spectrometry (Nexion 300x) with the condition of nebulizer gas flow parameters of 0.98 L/minute, the auxiliary gas flow of 1.20 L/minute, and plasma gas flow of 17 L/minute, and ICP Rf power 1400.

2.6. Vitamin B Content Analysis with LC-MS

Dried powder of harvested *P. ostreatus* (0.5 g) was placed in a 100 ml flask and mixed with 5 ml ammonium acetate, 10 mM, and 5 ml chloroform. The mixture was shaken with a shaker for 5 minutes, and the precipitate and supernatant were separated

by centrifugation (temperature <4°C, 7,000 rpm, 10 min). The resulting supernatant (1 ml) was taken into the LC-MS by a 10 L injection, and the LC-MS instrument was C18 column 4.6 x 250 mm, flow rate 1 ml/min (buffer phosphate: acetonitrile), column oven temperature 40°C, and measurement was conducted for 28 min.

2.7. Statistical Analysis

All data values were the average triplicate determinations expressed with the standard deviation (SD). The student's t-test was used to detect any significant differences between or within groups during stimulation to primordia initiation. Differences in means were statistically significant at a confidence level of 5% (P<0.05).

3. Results

3.1. Mineral Elements and Toxic Element Contents

Variation in coconut coir composition as a growth medium for the cultivation of *P. ostreatus* is presented in Table 1. The stimulation to primordia initiation ranged from 9 to 24 days, and the lowest time was observed in F1 (24 days), F2 (19 days), F3 (18 days), and F4 (16 days), while the fastest was observed in F5 (9 days).

Table 2 showed the Ca, Cr, Cu, Fe, Mg, Mn, K, P, Na, Se, and Zn of harvested *P. ostreatus* from variations

Table 2. Mineral and toxic element content (mg/kg) of medium growth variation (Coconut Coir)

Mineral	Medium growth variation (% coconut coir (w/w))				
	F1 (100%)	F2 (75%)	F3 (50%)	F4 (25%)	F5 (0%)
Ca (Calcium)	4,346	598	305	228	Nd
Cr (Chromium)	Nd	0.016	Nd	0.066	Nd
Cu (Copper)	2.07	Nd	Nd	0.353	Nd
Fe (Iron)	Nd	Nd	Nd	Nd	Nd
Mg (Magnesium)	313	283	273	266	189
Mn (Manganase)	1.56	15.3	0.003	0.934	Nd
Mo (Molybdenum)	Nd	0.008	0.012	0.002	Nd
K (Potassium)	26,909	25,019	22,234	21,955	17,494
P (Phosphorus)	1,136	695	848	643	421
Se (Selenium)	0.623	0.061	Nd	0.049	Nd
Na (Sodium)	Nd	23.8	Nd	Nd	Nd
Zn (Zinc)	15.4	3.41	12.4	5.94	Nd
Toxic element					
As (Arsenic)	Nd	Nd	Nd	0.002	0.029
Cd (Cadmium)	0.058	0.015	0.024	0.018	0.047
Pb (Lead)	0.525	Nd	Nd	Nd	Nd
Hg (Mercury)	0.012	Nd	Nd	Nd	Nd
Ni (Nickel)	Nd	Nd	Nd	Nd	Nd

Nd: Not detected

in coconut coir composition for growth mediums. Harvested *P. ostreatus* cultivated on variation 100% composition of coconut coir (F1) as medium was the highest source of potassium (26,909 mg/kg), followed by F2 (25,019 mg/kg), F3 (22,234 mg/kg), F4 (21,995 mg/kg), and F5 (17,494 mg/kg). The highest Ca content was recorded at medium F1 (4,346 mg/kg), and this value was significantly different from the other growth medium F2 (598 mg/kg), F3 (305 mg/kg), and F4 (228 mg/kg). The amounts of phosphorus were detected at growth medium F1 (1,136 mg/kg), followed by F2 (695 mg/kg), F3 (848 mg/kg), F4 (643 mg/kg), and F5 (421 mg/kg). The maximum Mg levels (313 mg/kg) was obtained at F1, followed by F2 (283 mg/kg), F3 (273 mg/kg), F4 (266 mg/kg) and F5 (189 mg/kg). The highest Zn concentration (15.4 mg/kg) was obtained at F1, followed by F3 (12.4 mg/kg), F4 (5.94 mg/kg), and F2 (3.41 mg/kg), but was not detected at F5. The highest content values (15.3 mg/kg) were obtained at F2, followed by F1 (1.56 mg/kg), F4 (0.934 mg/kg), and F3 (0.003 mg/kg), but was not detected at F5. The highest Cu concentration (2.07 mg/kg) was obtained at F1, followed by F4 (0.353 mg/kg), but was not detected at F2, F3, and F5. The greatest quantities (0.623 mg/kg) were obtained at F1, followed by F2 (0.061 mg/kg), and F4 (0.049 mg/kg), but was not detected at F3 and F5. The maximum levels of sodium (23.8 mg/kg) were only obtained at F4. The highest chromium content (0.066 mg/kg) was shown at F4, followed by F2 (0.016 mg/kg), while it was not detected at F1, F3, and F5. The highest cadmium content was shown at F1 (0.058 mg/kg), followed at F5 (0.047 mg/kg), F3 (0.08 mg/kg), F4 (0.018 mg/kg), and F5 (0.015 mg/kg). Mercury (0.012 mg/kg) and Lead (0.525 mg/kg) was also only detected at F1. Arsenic was only detected at F4 (0.002 mg/kg) and F5 (0.029 mg/kg).

3.2. Vitamin B Content

Figure 1 showed the chromatogram of vitamin B in a different medium of growth. In contrast, Table 4 showed the vitamin B complex screening results from *P. ostreatus* grown on different coconut coir medium compositions. Vitamin B1 (thiamine) with a retention time of 3.630 mins, B3 (niacin) with a retention time of 4.741 mins, B6 (pyridoxine) with a retention time of 8.217 mins, and B12 (cyanocobalamin) with a retention time of 14.358 mins were detected in the

F1-F5 media. In contrast, vitamin B5 (pantothenic acid) with a retention time of 13.173 mins was only detected in the F5 medium.

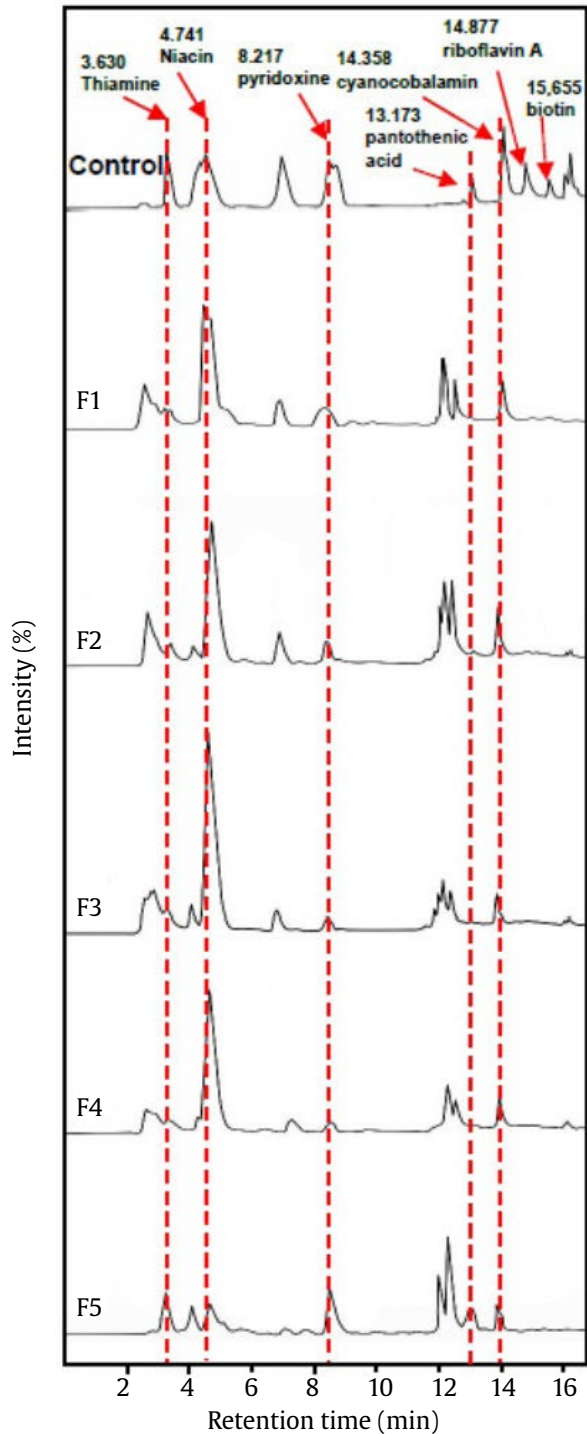


Figure 1. Chromatogram of vitamin B

4. Discussion

4.1. Mineral Elements and Toxic Element Contents

Mushrooms have been identified as an excellent food source to alleviate malnutrition in developing third-world countries. Due to mushrooms having their flavor, texture, nutritional value, and high productivity per unit area; therefore, it is economically significant in the global food industry (Wolff *et al.* 2008). *P. ostreatus* is the most cultivated mushroom due to its taste, ease of growth, cheapness and has bioactivities as antimicrobials (Wolff *et al.* 2008) and antitumor (Gern *et al.* 2008). Variation in coconut coir composition as a growth medium for the cultivation of *P. ostreatus* is presented in Table 1. The stimulation to primordia initiation ranged from 9 to 24 days, and the lowest time was observed in F1 (24 days), while the fastest was observed in F5 (9 days). These results are significantly different from the study by Ahmed *et al.* (2013), where *Pleurotus* strains took 7-10 days for fist primordia. Utami and Susilawati (2017) also reported that cultivated *P. ostreatus* on different sawdust growth media took 6-8 days to produce the first primordia. It degraded lignin and cellulose into simple carbohydrates used for protein synthesis. The complex compounds (lignin and cellulose) in the growth medium were composted for two days and broken down by microorganisms to extract simple compounds that *P. ostreatus* can digest. Cellulose will be parsed into glucose by enzymes used as nutrients and absorbed into the cell. The weathering process was slower and

took longer because lignin is resistant to degradation. During incubation, *P. ostreatus* mycelium spread between the growth medium particles, increasing the mycelium and contact surface. The increased contact surface resulted in optimal nutrient uptake by the growth medium. Mycelium is an energy source produced from the breakdown of cellulose and lignin to break down the coarse fibrous component of the medium utilized to achieve optimum development through cell compartment formation (Utami and Susilawati 2017). A fruiting body is formed from spacious underground mycelia (hyphae) by fructification (Kalac 2010). Meanwhile, a fruiting body of *P. ostreatus* has great nutritional value and is recommended daily for humans (Piska *et al.* 2017).

The mineral content is relevant given the prevalence of *Pleurotus* mushrooms as a food source. Table 2 showed the Ca, Cr, Cu, Fe, Mg, Mn, K, P, Na, Se, and Zn of harvested *P. ostreatus* from variations in coconut coir composition for growth medium. K and Ca were the most abundant essential elements in the current study compared to other minerals. The mineral content analysis enables the nutritional quality of food used to be evaluated by ICP-MS. The minerals and poisonous factors were compared to the RDA (Recommended nutritional allowances) and tolerable top consumption for Ca, Cr, Cu, Fe, Mg, Mn, K, P, Na, Se, Zn, or PTWI (Provisional tolerable weekly intake) for Ca, Cr, Cu, Fe, Mg, Mn, K, P, Na, Se, Zn or PTWI (Provisional tolerable weekly intake) (Table 3). To ensure that the mushroom grown on coconut coir is safe.

Table 3. Literature data on the trace element content (mg/kg) in *Pleurotus ostreatus*, recommended nutrient intake (mg/day), and tolerable upper intake levels (mg/kg body weight) for trace elements by the FAO/WHO

Macro and Micronutrient	<i>P. ostreatus</i> ^a	Recommended Nutrient Intake (RNI)/ Adequate Intakes (AI) for adults	Tolerable upper intake (UL) for adults
Ca (Calcium)	190-1,500	(RNI) 1,000-1,200 ^b	2,500 ^c
Cr (Chromium)	0.1-16.3	(RNI) 0.025-0.035 ^d	1 ^d
Cu (Copper)	19-50	(AI) 1.6 ^e	10 ^f
Fe (Iron)	33-550	(AI) 1.13-1.37 ^e	45 ^f
Mg (Magnesium)	165-2,300	(AI) 310-420 ^e	-
Mn (Manganase)	5-31.4	(AI) 3.0 ^g	9.0 ^h
Mo (Molybdenum)	5.8-14.7	(AI) 0.045 ^h	2 ^h
K (Potassium)	2,184-5,100	(RNI) 3,500 ⁱ	-
(Phosphorus)	6,180-13,390	(RNI) 700 ^e	4,000 ^h
Se (Selenium)	0.11-0.55	(RNI) 0.034 ^b	0.4 ^j
Na (Sodium)	250-440	(AI) 1,500 ^h	2,300 ^h
Zn (Zinc)	25-265	4.3-6.6 ^b	45 ^b
Toxic element		Provisional tolerable weekly intake (PTWI) ^k	
As (Arsenic)	0.0025-1.0	0.015	
Cd (Cadmium)	0.28-5.39	0.007	
Pb (Lead)	0.67-0.91	0.025	
Hg (Mercury)	0.5-2.0	0.005	
Ni (Nickel)	1.5-31.5		

^a(Siwulski 2017), ^bWHO (2004), ^cInstitute of Medicine (IOM 2011), ^dEuropean Food Safety Authority (EFSA 2014), ^eEFSA (2015), ^fIOM (2001), ^gEFSA (2013), ^hIOM (2006), ⁱWHO (2012), ^jIOM (2011), ^k(Kalac 2010)

Harvested *P. ostreatus* cultivated on variation 100% composition of coconut coir (F1) as a growth medium was a good source of potassium (26,909 mg/kg). This value was not significantly different from Recommended Nutrient Intake (RNI), approximately 2,184-5,100 mg/kg (Wani *et al.* 2010). More potassium (K) in *P. ostreatus*, suggesting that it might help decrease blood pressure, prevent osteoporosis and keep bones strong (Yusuf *et al.* 2007). The consumption can supply the amount of potassium (K) recommended for adults, 3,500 mg/day, considering the obtained result (Table 3).

The high concentration of calcium (Ca) in the *P. ostreatus* makes it an essential meal for people's formation and upkeep of boned and regular functioning of nerves and muscular tissues (Gasecka *et al.* 2016). The highest Ca content was recorded at growth medium F1 (4,346 mg/kg). Furthermore, the level of Ca in the *P. ostreatus* cultivated with 100% coconut coir as a growth medium was higher than in another published report (190-1,500 mg/kg, Table 3) (Siwulski *et al.* 2017); therefore, the consumption can supply the amount of Ca recommended for adults 1,200 mg/day (Table 3).

Phosphorus (P) is an important constituent of nucleic acid and essential for bone and tooth formation and acid-base balance. The amounts of phosphorus were detected at growth medium F1 (1,136 mg/kg), and these values were lower than in the previous study (6,180-13,390 mg/kg) (Siwulski *et al.* 2017), as shown in Table 3. The recommended dose for adult males or females is 700 mg/day, and the consumption can alleviate the malnutrition of phosphorus.

Magnesium (Mg), which is essential as an important cofactor for certain enzymes in many biochemical processes, has also been determined and compared. The maximum Mg levels (313 mg/kg) were obtained at F1, and these values were similar to available literature data (165-2,300 mg/kg) (Siwulski *et al.* 2017), as shown in Table 3. The consumption of *P. ostreatus* is enough to supply Mg recommended for adults 310 mg/day, considering the obtained result (Table 3).

Zinc (Zn) is an enzyme component involved in the synthesis and breakdown of various biomolecules, including carbohydrates, protein, nucleic acid, and

lipids, in the metabolism of other trace elements (Gasecka *et al.* 2016). Zn-metallothionein and the enzyme Cu-Zn superoxide dismutase have antioxidant properties in detoxifying reactive oxygen species (ROS) such as OH, O₂⁻, and H₂O₂ (Prasad *et al.* 2004). The highest Zn concentration (15.4 mg/kg) was obtained at F5 but was not detected at F1. These results were lower than the previous report (25-265 mg/kg) (Siwulski *et al.* 2017) shown in Table 3. The recommended daily zinc intake for adults is 4.3-6.6 mg/day, and the amount of zinc in *P. ostreatus* is sufficient to meet this need.

Manganese (Mn) is a mineral required for the activity of many enzymes (Ita *et al.* 2008). The highest content values (15.3 mg/kg) were obtained at F2 but were not detected at F5. These results were similar to another published report (5-31.4 mg/kg, Table 3) (Siwulski *et al.* 2017). The recommended dose for adults, male or female, is 3.0 mg/day; therefore, the consumption of *P. ostreatus* is enough to alleviate the malnutrition of manganese.

Copper (Cu) is required for all eukaryotes to respiration. (Altun *et al.* 2017). The highest Cu concentration (2.07 mg/kg) was obtained at F1, followed by F4 (0.353 mg/kg), but was not detected at F2, F3, and F5. These results were significantly different from the previous report (19-50 mg/kg) (Siwulski *et al.* 2017) shown in Table 3. The daily amount of 1.6 mg of copper suggested for healthy adult males and females may be alleviated by ingesting *P. ostreatus*.

Selenium (Se) is a component of antioxidant enzymes through amino acids (selenocysteine, selenomethionine) and proteins (Gasecka *et al.* 2016; Riaz and Mehmod 2012). The greatest quantities (0.623 mg/kg) were obtained at F1 but were not detected at F3 and F5. These results were higher than in previous studies (0.11-0.55 mg/kg) (Siwulski *et al.* 2017). Therefore, the consumption of *P. ostreatus* is enough to supply the amount of Se recommended for adults 0.034 mg/day (Table 3).

Normal cell function, plasma volume maintenance, acid-base balance, and nerve impulse transmission require sodium to function properly (Rubino and Franz 2012). The maximum levels (23.8 mg/kg) were only obtained at F4. This result was lower than other published reports (250-440, Table 3) (Siwulski *et al.*

2017). Due to the lowest quantities of Cu, harvested *P. ostreatus* does not supply the amount recommended Na for adults at 1,500 mg/day (Table 3).

Chromium (Cr) is a fundamental trace element in adjusting many metabolic systems such as metalloenzymes in the body. Furthermore, it regulates fat and carbohydrate metabolism and stimulates the synthesis of fatty acids and cholesterol, vital for brain function and other bodily processes (Mertz 1993). Mounting evidence indicates that Cr is essential for standard glucose tolerance to optimally regulate insulin action by enhancing the receptor activity and increasing glucose tolerance with signal transduction and insulin sensitivity (Chen *et al.* 2009). The highest chromium content (0.066 mg/kg) was shown at F4, while it was not detected at F1, F3, and F5. Even lower than the previous study (0.1-16.3 mg/kg) (Siwulski *et al.* 2017), the consumption of *P. ostreatus* is enough to alleviate the chromium deficiency. The recommended dose for adult males or females is 0.025-0.035 mg/day (Table 3). Hemoglobin and cytochrome production need iron (Fe), a nutrient essential for cellular respiration and oxygen transport in red blood cells. However, iron was not detected in all variations of coconut coir composition as a growth medium for the cultivation of *P. ostreatus*.

The trace element values in *P. ostreatus* differed depending on the growing region and genetic structure species. This can be attributed to ecosystem-determined differences in growth medium composition and significant differences in individual metal uptake by mushrooms (Wolff *et al.* 2008). Other studies have detected phosphorus levels (2.81 mol m⁻³) and potassium (20.64 mol m⁻³ in saturated medium) in coconut coir. On the other hand, coconut coir has calcium (2.44 mol m⁻³) and magnesium (2.01 mol m⁻³) in a saturated medium (Abad *et al.* 2002) numerically.

Harvesting mushrooms grown on a variety of coconut coir was examined to determine the level of toxic altitudes of convinced elements. This is because mushrooms are known to uptake and bio-accumulate essential mineral elements and some polluting toxic elements in high concentrations from the growth medium (Kalac 2001). Heavy metal accumulation is influenced by species, growth medium composition, mycelium age, and fruitification intervals (Kalac and Svoboda 2000). The absorption and accumulation

of mineral elements, including toxic elements, are influenced by the composition of the growth medium. The inclusion of numerous elements in the growing medium, both non-crucial and nutritional, generally involves a comparable increase in their content in the fruiting bodies, as demonstrated previously (Rzymiski *et al.* 2016). Besides nutritionally crucial elements, the existing evaluate the content material of arsenic, cadmium, lead, mercury, and nickel may pose a capability hazard for human health. The reported content of the toxic element of *P. ostreatus* with variation in coconut coir composition as a growth medium for the cultivation is presented in Table 2.

Mushrooms are known for their ability to accumulate cadmium (Moliszewska *et al.* 2015), linked to the presence of a binding compound (cadmium-myochophospatin), which is a genetically inherited feature (Kalac and Svoboda 2000; Leski and Rudawska 2005). Cadmium (Cd) is accumulated mainly in the kidneys and liver, and its level in blood serum increases considerably following mushroom consumption. Excessive exposure to Cd can result in osteomalacia (a chronic renal disease resulting in hypercalciuria, proteinuria, and glycosuria) (Sherlock 1984). The food and Agriculture Organization establish the maximum level for certain contaminants in foodstuffs. The World Health Organization stipulates the weekly intakes of Cd (0.42-0.49 mg) (39) and the highest content was shown at F1 (0.058 mg/kg), followed at F5 (0.047 mg/kg), F3 (0.08 mg/kg), F4 (0.018 mg/kg), F5 (0.015 mg/kg). Besides, F1 also had the highest selenium and zinc, and Se protects against Cd toxicity by reducing metal incorporation and intercellular interactions, consistent with findings from other living organisms (Munoz *et al.* 2007). Sufficient amounts of Zn in F1 are also required to counteract Cd's toxic effects. In cultivated *P. ostreatus*, the maximum Cd content allowed by European Union regulations is 2.0 mg/kg of dry matter at 90% humidity (42). Cd's provisional tolerable weekly intake (PTWI) is 0.007 mg/kg body weight (Table 3).

Mercury (Hg, 0.012 mg/kg) only was detected in F1; however, selenium's protective effect against toxicity has been documented (Suzuki and Ogra 2001). In animals, the selenoprotein complex was formed by an equimolar (mercury-selenium), a molecule that helps prevent mercury from reaching the body's

organs (Leonardi and Jackowski 2007). According to (Nnorom *et al.* 2012), *P. ostreatus* contains 0.028–0.031 mg/kg.dm of Hg in the caps and 0.028–0.037 mg/kg.dm in the stipes, while the provisional tolerable weekly intake (PTWI) for Hg is 0.005 mg/kg body weight (Table 3).

Lead (Pb, 0.525 mg/kg) was also only detected at F1, and the maximum level for specific contaminants in foodstuffs established by the food and Agriculture Organization with the World Health Organization stipulates the weekly intakes of Pb (1.5–1.75 mg) for adults (Leski and Rudawska 2005). In addition, the European Union Regulation allows for a maximum Pb content of 3.0 mg/kg.dm in cultivated *P. ostreatus* (assuming 90 percent moisture) (Gucia *et al.* 2012). Therefore, the provisional tolerable weekly intake (PTWI) for Pb is 0.025 mg/kg body weight (Table 3).

Meanwhile, arsenic (As) was only detected at F4 (0.002 mg/kg) and F5 (0.029 mg/kg). The provisional tolerable weekly intake (PTWI) for As is 0.015 mg/kg body weight (Table 3), and nickel was not detected in all variations. Hazardous metals such as As, Cd, Pb, and Hg were found in *P. ostreatus*. They attributed it to the mushroom becoming toxic and accumulating huge amounts of these elements in its coconut coir growth medium. Environmental factors such as metal concentration in a growth medium, pH, organic matter, contamination by atmospheric deposition, and fungal factors such as mushroom species and age, development of mycelium and fruit bodies, and morphological portion influence the accumulation of these elements in macrofungi (Garcia *et al.* 1998). According to a new study, cooking and microwaving mushrooms with water may minimize

the bioavailability of hazardous components in the human gastrointestinal system (Kalac *et al.* 2010).

4.2. Vitamin B Contents

Oyster mushrooms are a rich source of vitamin B, especially niacin and folates, compared to grown vegetables, making them a vital nutrient source to consider (9). The analysis of vitamin B was performed using HPLC, where F1–F5 showed the presence of vitamins B1, B3, B6, and B12. Vitamin B3 has an active form of NAD and NADP that plays an essential role in the metabolism of carbohydrates and fats. Vitamin B6 has an active form of pyridoxal phosphate (PLP), a coenzyme in the metabolism of amino acids. However, vitamin B5 (pantothenic acid) was only detected in F5, which is needed to synthesize coenzyme-A (CoA) in the metabolism of fatty acids (Leonardi and Jackowski 2007). Table 4 showed the results of vitamin B screening from *P. ostreatus* grown on different coconut coir growth medium compositions. The results of the present study are similar to those (Jonathan *et al.* 2012) that cultivated *P. ostreatus* on cotton wastes, rice straw, and sawdust growth medium content B1 (thiamine), B2 (riboflavin), B3 (niacin), and B5 (pantothenic acid).

Cultivating *P. ostreatus* on coconut coir as the growth medium is a very reliable and profitable option. Besides the low health risk of the toxic metal, different compositions of 100%, 75%, 50%, 25%, and 0% increased the trace elements and vitamin B. The trace element contents on 100% coconut coir growth medium are better than the Sengon sawdust. Therefore, the *P. ostreatus* cultivation on coconut coir may become valuable nutritional resources to

Table 4. Vitamin composition of *P. ostreatus* cultivated on different agro-industrial wastes

Vitamin	Medium growth variation (% coconut coir (w/w))					Literature data (Jonathan <i>et al.</i> 2012)		
	F1 (100%)	F2 (75%)	F3 (50%)	F4 (25%)	F5 (0%)	Cotton wastes	Rice straw	Sawdust
B ₁ (Thiamine)	+	+	+	+	+	+	+	+
B ₂ (Riboflavin)	-	-	-	-	-	+	+	+
B ₃ (Niacin)	+	+	+	+	+	+	+	+
B ₅ (Pantothenic acid)	-	-	-	-	+	+	+	+
B ₆ (Pyridoxine)	+	+	+	+	+	-	-	-
B ₇ (Biotin)	-	-	-	-	-	-	-	-
B ₁₂ (Cyanocobalamin)	+	+	+	+	+	-	-	-

-: Absent, +: Present

alleviate malnutrition and dispose of coconut coir in an environment-friendly manner.

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