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Research / Araştırma

MINERAL ELEMENTS OF WHITE, GREY, YELLOW AND PINK OYSTER MUSHROOMS (HIGHER BASIDIOMYCETES)

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Abstract

Oyster mushroom has ecological importance in maintaining balance in the environment by recycling chemical elements between the soil, organisms and the atmosphere by industrial applications to produce highly protein foods when treat and clean up pollutants in same time. Minerals value (C, N, Co, Pb, Fe, Ni, Cu, Zn, Cd and Mn) of fruiting bodies of four oyster mushrooms species; *Pleurotus ostreatus* (grey), *P. ostreatus* (white), *P. cornucopiae* var. *citrinopileatus* (bright yellow) and *P. salmoneostramineus* (pink), were investigated on three mixtures; F1 (wheat straw alone 100%), F2 (wheat straw 70%, white sawdust 20% and Iraqi date palm fiber "fibrillum" 10% mixture) and F3 (wheat straw 50%, white sawdust 30% and fibrillum 20% mixture). The kinds of substrates showed significant (P<0.05) differences of mineral composition of mushroom that due to metal content of each substrate, whereas the mixture which composed from one substrate was poorer in mineral value compared with others which composed from more one. Generally, Fe, Ni and Cd have been increased in substrates, also increased in fruiting bodies of oyster mushroom. These mineral levels were below the safety limits defined by FAO/WHO for weekly Required Dietary Intake (RDI).

Keywords: *Pleurotus* spp., nutritional value, wheat straw, white sawdust, date palm fiber.

BEYAZ, GRİ, SARI VE PEMBE İSTİRİDYE MANTARLARININ (YÜKSEK MANTARLAR) MİNERAL MADDE İÇERİĞİ

Özet

İstiridye mantarları ekonomik öneme sahip olup toprak, organizmalar ve hava arasında kimyasal elementlerin döngüsünü sağlayarak çevresel dengenin korunmasını sağlarlar. Endüstriyel uygulamalarla yüksek proteinli gıdalar elde edilirken aynı zamanda topraktan kirletici kimyasalları temizlerler. Bu araştırmada üç farklı (F1 %100 buğday samanı, F2 %70 buğday samanı + %30 talaş + %20 fibrillum adı verilen Irak hurma ağacı fiberi karışımı) substratta geliştirilmiş dört istiridye mantarının *Pleurotus ostreatus* (gri), *P. ostreatus* (beyaz), *P. cornucopiae* var. *citrinopileatus* (parlak sarı) ve *P. salmoneostramineus* (pembe) mineral madde içeriği (C, N, Co, Pb, Fe, Ni, Cu, Zn, Cd ve Mn) belirlenmiştir. Substratların mineral içeriğine bağlı olarak mantarların da mineral içeriği önemli derecede (P<0.05) farklı olmuştur. Genel olarak substratların Fe, Ni ve Cd içeriği yüksek bulunurken, bu durum mantarlara da yansımıştır. Mineral içerikleri FAO/WHO tarafından açıklanan haftalık gerek duyulan alım için (weekly Required Dietary Intake; RDI) güvenlik limitlerinin altındadır.

Anahtar kelimeler: *Pleurotus* spp., besin değeri, buğday samanı, beyaz talaş, palmiye ağacı fiberi.

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INTRODUCTION

After white button mushroom; the oyster mushroom is the second most important mushrooms in production in the world, *Pleurotus* species are excellently edible and nutritious, rank among one of the most widely cultivated mushrooms in the world, accounting for 25% of total world production of cultivated mushrooms (1). This fungus is important to bio-convert cellulosic matters to a rich protein food (2, 3).

Pleurotus spp. possesses important nutritional and medicinal values. The animal proteins cannot using as protein source alone because of their expensive prices; therefore, fruiting bodies of oyster mushrooms were used instead of meat, that due to moderate protein content and it is source for essential amino acids, mineral and vitamins (4). *Pleurotus ostreatus* is important source for trace elements and its nutritional source low caloric value (5). *Pleurotus cornucopiae* was one of important medicinal and edible mushroom which has antihypertensive effect on spontaneously hypertensive rats (6) and antimicrobial effect using its gold (2) and silver nanoparticles (7). The Traditional Chinese Medicine first suggested *Pleurotus*, is almost ideal for diets designed, to prevent cardiovascular diseases because of its high fiber content, proteins, microelements and low caloric value (8). *Pleurotus* species have high medicinal value due to possess significant anti-inflammatory, antiviruses (9), antioxidant, anticancer (10), anti-parasitic (11), antifungal (12), anti-yeast (7) and anti-bacterial activities (13).

Pleurotus spp. can be cultivated on a wide variety of substrates containing lignin, cellulose and hemicellulose (14) such soybean straw, rice straw, paddy straw, coffee pulp, cotton wastes, cotton seed hulls, corn cobs waste (15), bean straw, crushed bagasse, molasses wastes (16), wheat straw, date palm wastes (2, 17-20), handmade paper wastes, industrial cardboard wastes (3,21), rice bran with sawdust (22) and some their combination. The substrates that prepared from date palm wastes have low nitrogen, therefore; Hassan (23) added some nutrients such urea and K_2SO_4 to date palm wastes (fiber, stalk and base stalk). While, Owaid et al. (19) added phosphate rock to raise the nutritional value of date palm fiber, wheat straw and white sawdust because of mineral value of this fertilizer (24). *Pleurotus ostreatus* enabled to remediate pollutants with present heavy metals (25). *Pleurotus* spp. had no any mineral value testes when grown on some date palm wastes such empty palm fruit bunch with other cellulosic wastes (26, 27) for production *Pleurotus sajor-caju* and *Pleurotus ostreatus*, date palm leaves and alfalfa to produce oyster mushrooms (28), date palm leaf to cultivate *P. ostreatus* and *P. florida* in Iran (17) and date palm fiber, wheat straw and white sawdust to produce *Pleurotus ostreatus* (grey), *P. ostreatus* (white), *P. cornucopiae* var. *citrinopileatus* (bright yellow) and *P. salmoneostramineus* (pink) (19). But Hassan (23) and Alananbeh et al. (29) calculated that only for specie *Pleurotus ostreatus* which was cultivated on date palm wastes in Iraq and Saudi Arabia respectively.

However, no reference is found in literature regarding the comparison of determining mineral value of many species of *Pleurotus* fruiting bodies grown on substrates containing from date palm fiber and other substrates obtained thereof. Thus, the objective of this study is calculate mineral elements value of four *Pleurotus* spp. and then knows the daily intake levels of elements in produced oyster mushrooms on various cellulosic sources in Iraq.

MATERIALS AND METHODS

Sampling

Twelve fruiting bodies types from four oyster mushrooms species were investigated. *Pleurotus ostreatus* (grey oyster), *Pleurotus ostreatus* (white oyster), *Pleurotus cornucopiae* var. *citrinopileatus* (bright yellow oyster) and *Pleurotus salmoneostramineus* (pink oyster) were harvested from three substrates from College of Science, University of Anbar, Iraq. Three locally agro-residual wastes wheat straw (1-5) cm, white sawdust from factories of wood and fibers of date palm *Phoenix dactylifera* L., called (Fibrillum), which first chopped into small pieces (5x5) cm and prepared mixtures (as shown in Table 1) with 5% of phosphate rock powder. Phosphate rock samples were taken at random at the location of State Company For Phosphate, Anbar; agro-substrate samples from Hit city agricultural lands.

Table 1. Formula of agro-substrates contents

Formula	Agro-substrates		
	Wheat straw	White sawdust	Date palm fibers
Formula 1 (Control) (F1)	100%	-	-
Formula 2 (F2)	70%	20%	10%
Formula 3 (F3)	50%	30%	20%

Mushroom and substrate samples were dried at 110 °C for 24 h until the weight constant. The dried samples were ground, then homogenized using an agate pestle and stored in polyethylene bottles until analysis (30).

Reagents

All reagents were of analytical reagent grade unless otherwise stated. Double deionized water was used for all dilutions. HNO_3 and HCl were of quality (E. Merck). All the plastic and glassware were cleaned by soaking in dilute HNO_3 and were rinsed with distilled water prior to use. The element standard solutions used for calibration were prepared by diluting a stock solution of 1000 mg/L (Pb, Cd, Co, Cr, Mn, Ni, Cu, Zn and Fe) supplied by Sigma.

Apparatus

Phoenix-986 (USA) atomic absorption spectrometer with deuterium background corrector was used in this study. Pb, Cd, Co, Cr, Mn, Ni, Cu, Zn and Fe in mushroom samples were carried out in an air/acetylene flame.

Microwave digestion

Dry mushroom sample (2 g) was placed in a beaker (100 ml capacity) and digested with 10 ml of HNO_3 (65%) and 2 ml of H_2O_2 (30%) in microwave digestion system for 10 min with 600 W and diluted to 25 ml with deionized water. A blank digest was carried out in the same way. For the agricultural substrates, also 2 g of sample was digested with 20 ml of HNO_3 (65%) and 5 ml of H_2O_2 (30%) in microwave digestion system for 23 min with 600 W and diluted to 25 ml with deionized water. A blank digest was carried out in the same way (30).

Statistical analysis

Experimental values are given as means. Statistical significance was determined by two variance (two ways) analysis (ANOVA) by using GenStat Discovery Edition computer program version 7 DE3 (VSN International Ltd., UK). Differences at $P<0.05$ were considered to be significant.

RESULTS AND DISCUSSION

The results, in Table 2, showed the ability of these fungi to absorb and bio magnify the mineral elements from next agro-substrates; F1 (wheat straw alone 100%), F2 (wheat straw 70%, white sawdust 20% and Iraqi fibrillum 10% medium) and F3 (wheat straw 50%, white sawdust 30% and Iraqi fibrillum 20% medium). Mineral elements value of agricultural substrates was appeared significant ($P<0.05$) values with all metals except cadmium and lead. F3 medium had significant ($P<0.05$) high content of elements Co, Fe, Ni, Cu, Zn and Mn metals in averages 0.60, 38.27, 0.93, 2.90, 2.44 and 4.65 mg/kg followed by F2 medium with all these metals, then decreased in F1 medium (control) to 0.47, 27.92, 0.50, 2.10, 1.03 and 1.98 mg/kg respectively. About elemental carbon, the high content was 244.33 g/kg for F3 significantly ($P< 0.05$), then decreased to 243.33 g/kg and 239.00 g/kg for F2 and F1 respectively; whereas the nitrogen content was 7.71 g/kg with F2 substrates compared with F1 (6.65 g/kg). C:N ratio of these mixtures reached to level between 34.06-40.20.

Table 2. Mineral elements content of agro-substrates based on dry weight (dw)

Formula of substrates	Mineral elements content										C:N
	mg/kg								g/kg		
	Co	Pb	Fe	Ni	Cu	Zn	Cd	Mn	C	N	Ratio
F1	0.47	0.21	27.92	0.50	2.10	1.03	0.14	1.98	239.00	6.65	38.50
F2	0.53	0.22	32.34	0.72	2.59	1.89	0.14	3.52	243.33	7.71	34.06
F3	0.60	0.23	38.27	0.93	2.90	2.44	0.15	4.65	244.33	6.65	40.20
LSD	0.068	0.059	0.697	0.071	0.206	0.276	0.028	0.176	1.489	0.541	0.176

Legend: F1 (wheat straw alone 100%), F2 (wheat straw 70%, white sawdust 20% and date palm fiber "fibrillum" 10% mixture) and F3 (wheat straw 50%, white sawdust 30% and fibrillum 20% mixture). LSD $P<0.05$.

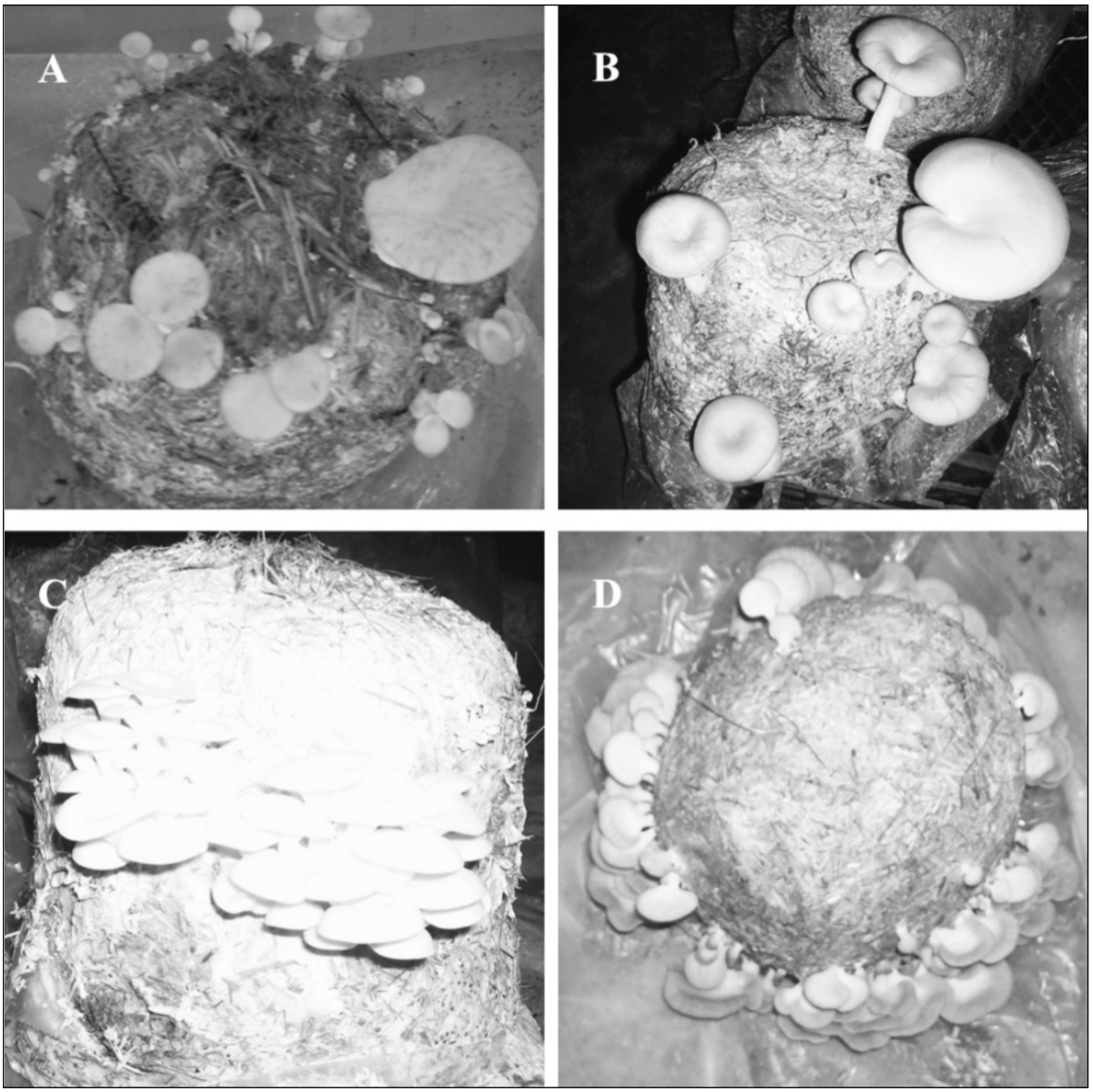

Figure 1. White, grey, yellow and pink oyster mushroom fruiting bodies
Legend: A: *Pleurotus ostreatus* (white), B: *Pleurotus ostreatus* (grey), C: *Pleurotus cornucopiae* var. *citrinopileatus* (yellow) and D: *Pleurotus salmoneostramineus* (pink).

Mineral value of fruiting bodies of *Pleurotus* spp. (Figure 1) was showed in Table 3 and Figure 2. The best significant (P<0.05) content of nitrogen was 5.99 g/kg of fruiting of *Pleurotus cornucopiae* which grew on F2 medium, while the low content was 3.72 g/kg in *Pleurotus ostreatus* (grey) which grew on F1 and F3 media. Cobalt content of fruiting bodies was 20.09 mg/kg as a higher content in *Pleurotus salmoneostramineus* which grew on F2 medium significantly (P<0.05). F2 medium effect on increasing content of Co in all mushrooms compared with F1 and F3 media except within *P. ostreatus* (white) at rate 7.25 mg/kg on F2 medium compered as 7.55 mg/kg and 9.60 mg/kg on F3 & F1 media respectively. While the lower content was 6.27 mg/kg by fruiting of *P. cornucopiae* within F1 medium.

Significantly (P<0.05), the content of lead was reached to 8.72 mg/kg followed by 7.94 mg/kg with *P. ostreatus* (white) on F2 and F3 respectively. The lesser lead value was 4.02 mg/kg by *P. ostreatus* (grey) on F3 medium. The best value of iron

Table 3. Mineral Value of *Pleurotus* spp. fruits based on dry weight (dw)

E.	*P. ostreatus* (grey)			*P. ostreatus* (white)			*P. cornucopiae* (yellow)			*P. salmoneos.* (pink)		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
N[a]	3.72	3.99	3.72	3.99	3.86	3.99	4.82	5.99	4.66	4.99	4.82	4.99
Co	12.15	13.82	10.98	9.60	7.25	7.55	6.27	12.05	9.60	12.64	20.09	10.29
Pb	5.49	6.47	4.02	6.57	8.72	7.94	4.90	5.59	5.78	7.64	5.39	4.31
Fe	24.60	23.72	26.36	22.34	37.34	29.89	35.87	28.42	33.71	22.93	26.66	26.56
Ni	0.10	9.41	5.29	0.98	2.06	18.03	12.15	34.40	39.69	12.25	2.74	3.04
Cu	6.08	6.08	5.88	11.27	11.37	11.27	7.55	11.86	9.60	6.76	7.35	7.35
Zn	27.54	26.26	25.19	30.38	30.18	30.48	31.16	31.26	34.40	44.10	45.37	43.32
Cd	2.16	1.96	1.96	2.94	3.72	3.43	3.43	2.06	3.33	4.12	4.21	4.41
Mn	2.84	2.84	3.04	3.14	3.43	2.45	3.82	3.82	3.23	4.90	11.47	10.68

Legend: E: mineral elements. (a) g/kg dry weight, (Others) mg/kg dw. F1: Dry fruiting bodies which grown on wheat straw 100% substrate, F2: Dry fruiting bodies which grown on wheat straw 70%, white sawdust 20% and date palm fiber 10% mixture, F3: Dry fruiting bodies which grown on wheat straw 50%, white sawdust 30% and date palm fiber 20% mixture. **LSD** $P<0.05$, N=0.878, Co=0.547, Pb=0.607, Fe=0.758, Ni=0.467, Cu=0.539, Zn=0.457, Cd=0.372, Mn=0.325.

37.34 mg/kg followed the value 35.87 mg/kg by *P. ostreatus* (white) on F2 medium and *P. cornucopiae* on F1 medium respectively, while the lesser value 22.34 mg/kg by fruiting bodies of *P. ostreatus* (white) on F1. Nickel value was changeable; its value in *P. ostreatus* (grey) on F1 medium was decreased to 0.10 mg/kg compared with higher content 39.69 mg/kg with *P. cornucopiae* on F3 medium. While the copper content was low with *P. ostreatus* (grey) around 6.08-5.88 mg/kg while the higher content 11.86 mg/kg with fruiting bodies of *P. cornucopiae* on F2

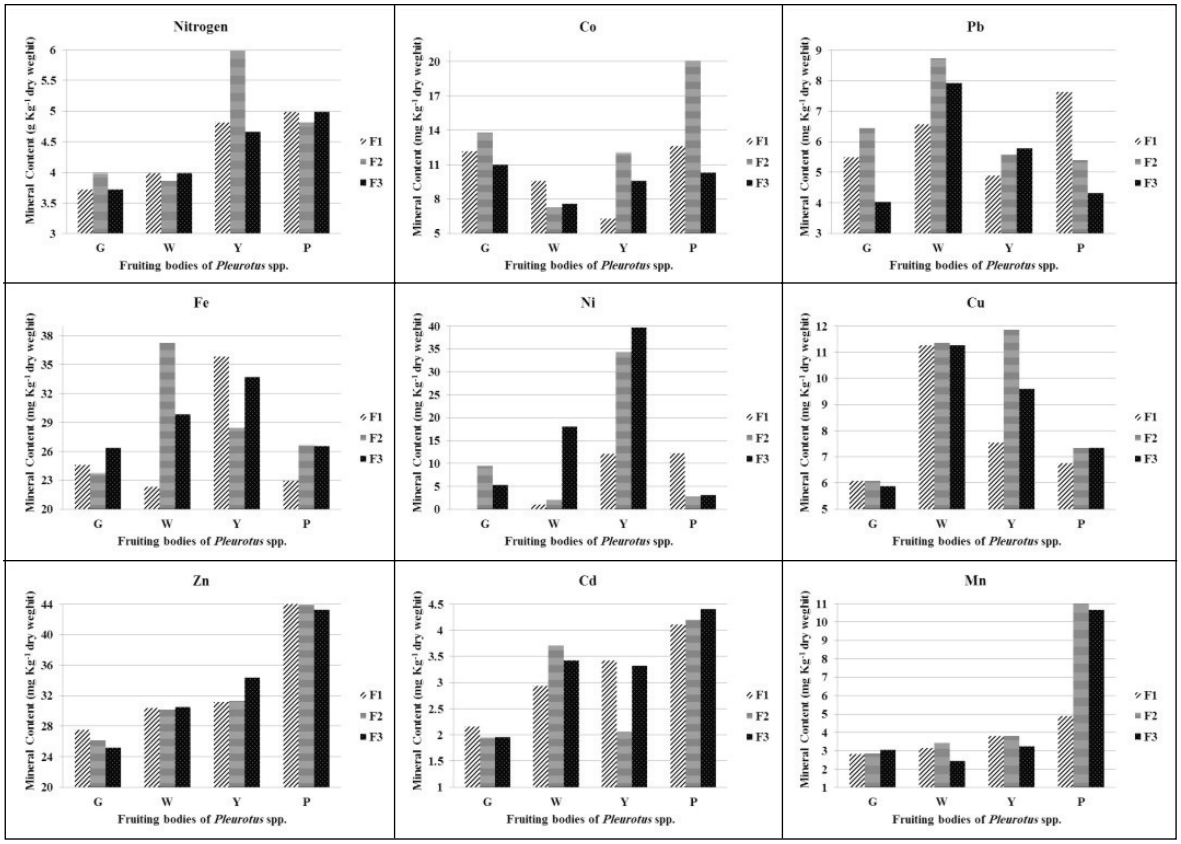

Figure 2. Mineral Value of fruiting bodies of oyster mushrooms (based on dry weight (dw))
Legend: G: Dry fruiting bodies of *P. ostreatus* (grey), W: Dry fruiting bodies of *P. ostreatus* (white), Y: Dry fruiting bodies of *P. cornucopiae*, P: Dry fruiting bodies of *P. salmoneostramineus*, F1: Formula of substrate of wheat straw 100% (Control), F2: Formula of substrate of wheat straw 70%, white sawdust 20% and date palm fiber 10%, F3: Formula of substrate of wheat straw 50%, white sawdust 30% and date palm fiber 20%.

medium, followed by *P. ostreatus* (white) around 11.27-11.37 mg/kg. Zinc levels within fruiting bodies of *P. ostreatus* (grey) firstly, *P. ostreatus* (white), *P. cornucopiae* and *P. salmoneostramineus* were increased respectively. The less value was 25.19 mg/kg of *P. ostreatus* (grey) on F3 and high value was 45.37 mg/kg of *P. salmoneostramineus* on F2 medium. The value of cadmium was 1.96 mg kg^{-1} as less value with *P. ostreatus* (grey) on F2 & F3 media compared with 2.16 mg/kg on F1 medium, whereas the high content was 4.41 mg/kg on F3 by *P. salmoneostramineus*. Finally, level of manganese reduced to 2.45 mg/kg in *P. ostreatus* (white) and increased to 11.47 mg/kg with *P. salmoneostramineus* on F2 medium.

The kinds of substrates showed clear differences of chemical composition of *Pleurotus* spp. fruiting bodies which due to mineral elements content of each formula/medium (Table 2). The F1 medium (only wheat straw) was poorer in chemical value than others which composed from more than one substrate (F2 & F3) that agreed with Hassan (23). Fruiting bodies of oyster mushroom that grown on F1 medium was poorer in mineral compared when grew on F2 and F3 medium. These results were congruent with results of Ahmed (31), chemically; the agro-substrate that composed from more than one carbon source was richer than the substrate that composed from one. Thus, these results appeared different chemical values according to species of oyster mushroom and type/formula of agricultural substrates.

From fruiting side, when iron, nickel and cadmium elements of substrate were increased, lead is increasing in fruiting bodies of all oyster mushroom species too. Whereas other elements content of fruiting bodies was changeable because of *Pleurotus* spp. ability to bio accumulate these minerals from substrate and ecosystem (32, 33). This matter is meaningful viz. elements levels of mushroom are important because of many of edible mushrooms accumulate high levels of elements such: Cd, Hg, Cu and Pb in their fruits (34). Nonetheless, this paper results were acceptable for consumer.

The accumulation of elements due especially to species of mushroom, partially on ecosystem and influence of eco-factors was determined difficultly (35), especially pH and organic matters of ecosystem that effect on concentrations of heavy metals in mushrooms' fruits (36). In some methods, the date palm wastes succeed in adsorption about 90% of calcium ion, 57.5% of Cd ion and 37.5% of Zn ion (37), subsequently that may be return to minerals content of date palm fibers (in F2 and F3 media) that influence on accumulation of minerals value in mushroom. But Tuzen (32) find a mushroom is accumulating heavy minerals such Cd, Cu and Zn in higher percentage compared with other minerals: Pb, Co, Cr, Mn, Ni and Fe. The Cd and Mn levels agreed with results of Kalac (38) that range between 0.5-5.0 mg/kg and 60-10 mg/kg based on dried mushroom, respectively. Finally, mineral elements levels of four species of oyster mushrooms were below the safety limits defined by FAO/WHO for weekly Required Dietary Intake (RDI) (39). Also, eating this food can be done without side effects because this food is consuming seasonally, that encourage using this fresh food because its ability to grow with simple methods easily (40).

CONCLUSION

Pleurotus spp. has ecological importance in maintaining balance of chemical elements in the ecosystem. Minerals value (C, N, Co, Pb, Fe, Ni, Cu, Zn, Cd and Mn) of fruiting bodies of four oyster mushrooms species; *P. ostreatus* (grey), *P. ostreatus* (white), *P. cornucopiae* var. *citrinopileatus* and *P. salmoneostramineus*, were investigated on three mixtures composed from variable ratio of wheat straw, white sawdust and Iraqi date palm fiber "fibrillum" with phosphate rock 5% as supplement. Chemically, the mixture which composed from more one substrate was richer in mineral elements compared with mixtures which composed from one. Also, Fe, Ni and Cd were increased in substrates, also increased in fruiting bodies of oyster mushroom. These mineral levels were below the safety limits defined by FAO/WHO for weekly Required Dietary Intake (RDI).

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