Nutraceutical Value of Four Oyster Mushroom Species, Higher Basidiomycetes

Dört İstiridye Mantar Türlerinin Besin Değeri, Yüksek Basidiomycetes

Research Article

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ABSTRACT

This work was achieved to determine the nutritional value (total protein, crude fiber, phenolic compounds, total carbohydrate, ash, dry matter, moisture content and pH) of four oyster mushrooms species namely; *P. ostreatus* (grey), *P. ostreatus* (white), *P. cornucopiae* var. *citrinopileatus* (yellow) and *P. salmoneostramineus* (pink), were investigated on three agro-substrates mixtures; S1 (wheat straw), S2 (70% wheat straw, 20% sawdust and 10% date palm fiber) and S3 (50% wheat straw, 30% sawdust and 20% date palm fiber) media. The variety of oyster mushroom showed significant ($P<0.05$) differences of nutritional value of oyster mushroom on various substrates. The mixture which composed from one substrate was poorer in mineral value than others which composed from more one. Generally, the higher protein content showed in *P. cornucopiae* (32.21%) compared with *P. ostreatus* (grey) (23.83%) as a lower value. *P. ostreatus* (grey) recorded total phenol, total carbohydrates and crude fibers 2.82 g/kg, 40.72% and 9.97%, while *P. salmoneostramineus* recorded 1.35 g/kg, 48.02% and 23.75% respectively. *P. ostreatus* (white) showed higher value of ash and dry matter (11.3% and 12.81%) than *P. ostreatus* (grey) and *P. salmoneostramineus* in values 7.0% and 9.93%, respectively.

Key Words
Protein, phenol, crude fibers, *Pleurotus spp.*

ÖZ

Bu çalışmada dört istridye mantar türünün besin değeri (total protein, ham selüloz, fenolik bileşikler, toplam karbohidrat, kül, kuru madde, nem içeriği ve pH) belirlenmiştir. *P. ostreatus* (gri), *P. ostreatus* (beyaz), *P. cornucopiae* var. *citrinopileatus* (sarı) ve *P. salmoneostramineus* (pembe), mantar türleri üç tarımsal karışımda S1 (buğday samanı), S2 (%70 buğday samanı, %20 talaş ve %10 hurma lifi) ve S3 (%50 buğday samanı, %30 talaş ve %20 hurma lifi) incelenmiştir. İstiridye mantarlarının çeşitli katkı maddeleriyle besin değerinin önemli ($p<0.05$) farklılıklar gösterdiği görülmüştür. Genel olarak, *P. cornucopiae* (%32.21), *P. ostreatus* (gri) (%23.83) karşılaştırıldığında daha yüksek protein içeriğine sahip olduğu görülmüştür. *P. ostreatus* (gri) toplam fenol, toplam karbonhidrat ve ham lif içeriği sırasıyla 2.82 g/kg, %40.72 ve %9.97 ve *P. salmoneostraminus* için sırasıyla 1.35 g/kg, %48.02 ve %23.75 olarak bulunmuştur. *P. ostreatus* (beyaz), kül ve kuru madde içeriğinin (%11.3 ve %12.81), *P. ostreatus* (gri) ve *P. salmoneostramineus* kül ve kuru madde içeriğinden (%7.0 ve %9.93) fazla olduğu bulunmuştur.

Anahtar Kelimeler
Protein, fenol, ham lifler, *Pleurotus* spp.

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INTRODUCTION

Oyster mushroom, *Pleurotus* spp., is a popular in most countries [1]. This edible mushroom is important for bioconversion of lingo-cellulosic matters to fresh food [2]. *Pleurotus* spp. has been used as a food and drug [3]. This mushroom can be using cellulosic substrates easily as a carbon and energy source, like wheat straw, paddy straw, rice straw, corn cobs wastes, cotton wastes, soybean straw [4], bean straw, molasses wastes [5], paper wastes [6,7], wood sawdust [8], date palm wastes [9-13].

Pleurotus spp. is one of important medicinal and edible mushroom which has been used to protect against acute renal failure [14], its polysaccharides against cancer cells [15], antihypertensive against spontaneously hypertensive rats [16], antimicrobial effect using its silver and gold nanoparticles [3,17], to prevent cardiovascular diseases [18] and has anti-inflammatory, antiviruses [19], antioxidant, anticancer [20], antifungal [21,22], anti-yeast [17] and anti-bacterial activities [23]. Fruiting bodies of oyster mushrooms were used instead of meat as food, that due to moderate protein content and it is source for essential amino acids, mineral and vitamins [24]. *Pleurotus ostreatus* is important source for trace elements, high fiber and low caloric value [18,25].

Fruiting bodies which produced on commercial substrates are non-economic because of the high price of substrate especially wheat straw substrate. Thus must determine nutritional value of mushroom which cultivated on local substrates (date palm residues and wastes with other substrates) have low prices and available during year from side and to decrease the pollutions outcome from burning it from other side. However, no reference is found in literature regarding the comparison of determining nutritional value of many species of *Pleurotus* fruiting bodies cultivated on substrates containing date palm fiber and other agro-substrates obtained thereof. Thus, the objective of this study is calculating nutritional value of four *Pleurotus* spp. cultivated on three cellulosic matters in Iraq containing wheat straw, sawdust and date palm fiber.

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 mixtures; S1 (100% wheat straw), S2 (70% wheat straw, 20% sawdust and 10% date palm fiber) and S3 (50% wheat straw, 30% sawdust and 20% date palm fiber). Agro-substrate samples were taken from Hit city agricultural lands.

Determinations

Random samples of mushrooms were dried at 45°C until constancy of weight. The dried samples were weighted then the dry weight was calculated according to this equation: dry weight %= (dry weight/fresh weight) ×100 [26]. Also, humidity content was calculated according to equation of Haq et al. [26]; Humidity percent= (fresh weight-dried weight/fresh weight) ×100

The ion hydrogen concentration (pH) of powdered samples which extracted in distilled water at ratio (1:10) was recorded by using pH meter according to Liu and Price [27]. Ash content was determined by method of Haq et al. [26] by using this equation: ash%= (ash weight/dry weight) ×100. Protein content was calculated using nitrogen percent which analyzed using Kjeldahl method as this equation: protein%=nitrogen%×6.25 [28].

Total phenol was evaluated based on fresh mushroom using Arnow's method; the absorbance was recorded at 515 using spectrophotometer. Wile, total carbohydrate was calculated for dried samples using Phenol-Sulphuric Acid method and the absorbance was recorded at 490 using spectrophotometer as well [29]. The crude fiber of dried samples was calculated using Weende Gravimetric method according to the following equation: crud fibers= (w2-w3/w1) ×100 [30], with sign, that w1: weight of dry matter, w2: weight of sample after treatment and drying, w3: weight of ash.

Statistical Analysis

Experimental values are given as means. Statistical significance was determined by CRD using 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 ad DISCUSSION

Protein Content

Generally, Table 1 showed results of protein content in dried oyster mushrooms. *Pleurotus cornucopiae* var. *citrinopileatus* (bright yellow oyster mushroom) exhibited highest protein content 32.21% significantly ($P<0.05$) followed *Pleurotus salmoneostramineus* (pink oyster mushroom) at average 30.82%, while *Pleurotus ostreatus* (grey oyster mushroom) exhibited lower content 23.83% followed 24.66% by *P. ostreatus* (white oyster mushroom). The best content was recorded by *P. cornucopiae* which harvested from S2 medium (37.41%) significantly ($P<0.05$), whereas the lower content was 23.28% by *P. ostreatus* (grey) from S1 and S3 media, followed by *P. ostreatus* (white) in percent 24.11% when cultivated on S2 medium.

Total Phenol Content

Total phenolic value appears in Table 2, total phenol content has been determined based on fresh matter. The higher content was 3.04 g/kg for fruits of *P. ostreatus* (grey strain) on S3 medium, followed by fruits of *P. cornucopiae* (yellow strain) and *P. ostreatus* (grey strain) on S1 medium at content 2.95 and 2.83 g/kg respectively. Whereas, the lower content of total phenol was 1.22, 1.27 and 1.58 g/kg for fruits of *P. salmoneostramineus* on S2, S3 and S1 media, respectively. In general, *P. ostreatus* (grey) recorded higher content at average 2.82 g/kg significantly ($P<0.05$), followed by others *P. cornucopiae*, *P. ostreatus* (white) and *P. salmoneostramineus* at averages 2.44, 2.19 and 1.35 g/kg respectively.

Content of Carbohydrates

In general, *P. ostreatus* (grey) recorded higher significant ($P<0.05$) content at average 40.72% based on dry matter than fruits of *P. salmoneostramineus* which recorded lower value 28.02% (Table 3). Using of various cellulosic mixtures effected significantly ($P<0.05$) on carbohydrates content, which reached to 43.35% and 40.16% for *P. ostreatus* (grey) in case S2 and S3 media, respectively, compared with its fruits on the control (wheat straw, S1) with percent

Table 1. Protein percent in dry fruiting bodies of oyster mushroom species.

Agro-substrates	P. ostreatus (grey)	P. ostreatus (white)	P. cornucopiae (yellow)	P. salmoneostramineus (pink)	LSD ($P<0.05$)
S1	23.28	24.94	30.13	31.17	0.878
S2	24.94	24.11	37.41	30.13	
S3	23.28	24.94	29.09	31.17	
Mean	23.83	24.66	32.21	30.82	0.507

Legend: S1: Fruiting bodies which grown on wheat straw, **S2**: Fruiting bodies which grown on 70% wheat straw, 20% sawdust and 10% date palm fiber mixture, **S3**: Fruiting bodies which grown on 50% wheat straw, 30% sawdust and 20% date palm fiber mixture.

Table 2. Total phenol content in fresh fruiting bodies of oyster mushroom species.

Agro-substrates	*P. ostreatus* (grey)	*P. ostreatus* (white)	*P. cornucopiae* (yellow)	*P. salmoneostramineus* (pink)	LSD ($P<0.05$)
S1	2.83	2.74	2.95	1.58	0.312
S2	2.59	1.86	1.93	1.22	
S3	3.04	1.98	2.45	1.27	
Mean	2.82	2.19	2.44	1.35	0.180

Legend: S1: Fruiting bodies which grown on wheat straw, **S2**: Fruiting bodies which grown on 70% wheat straw, 20% sawdust and 10% date palm fiber mixture, **S3**: Fruiting bodies which grown on 50% wheat straw, 30% sawdust and 20% date palm fiber mixture.

Table 3. Total carbohydrates content in dry fruiting bodies of oyster mushroom species.

Agro-substrates	*P. ostreatus* (grey)	*P. ostreatus* (white)	*P. cornucopiae* (yellow)	*P. salmoneostramineus* (pink)	LSD (*P*<0.05)
S1	38.67	36.50	30.05	29.31	0.767
S2	43.35	37.31	28.97	26.93	
S3	40.16	32.56	30.39	27.82	
Mean	40.72	35.45	29.80	28.02	0.442

Legend: S1: Fruiting bodies which grown on wheat straw, **S2**: Fruiting bodies which grown on 70% wheat straw, 20% sawdust and 10% date palm fiber mixture, **S3**: Fruiting bodies which grown on 50% wheat straw, 30% sawdust and 20% date palm fiber mixture.

Table 4. Ash content in dried fruiting bodies of oyster mushrooms.

Agro-substrates	*P. ostreatus* (grey)	*P. ostreatus* (white)	*P. cornucopiae* (yellow)	*P. salmoneostramineus* (pink)	LSD (*P*<0.05)
S1	7.0	12.0	10.0	11.0	0.97
S2	5.0	9.0	9.0	8.0	
S3	9.0	13.0	10.0	11.0	
Mean	7.0	11.3	9.6	10.0	0.56

Legend: S1: Fruiting bodies which grown on wheat straw, **S2**: Fruiting bodies which grown on 70% wheat straw, 20% sawdust and 10% date palm fiber mixture, **S3**: Fruiting bodies which grown on 50% wheat straw, 30% sawdust and 20% date palm fiber mixture.

38.67%, followed by *P. ostreatus* (white) on S2 media (37.31%). While *P. salmoneostramineus* and *P. cornucopiae* recorded 26.93% and 28.97% on S2 medium; *P. salmoneostramineus* showed content 27.82% on S3 medium at least percent in this nutritional matter.

Ash Content

The lower ash content was 5% and 7% for fruits of *P. ostreatus* (grey) significantly (*P*<0.05) on S2 and S1 media, respectively (Table 4). While the higher percent was 13% and 12% for *P. ostreatus* (white) on S1 and S3 media, respectively. In general, *P. cornucopiae* (yellow strain) and *P. salmoneostramineus* (pink strain) recoded a mean 9.6% and 10%, whiles *P. ostreatus* (grey and white strains) showed a mean 7% and 11.3% respectively.

Total Fibers Content

Generally, the lower percent of total crude fibers was 9.97% for *P. ostreatus* (grey), while the lower percent was 23.75% for fruits of *P. salmoneostramineus*. The last species showed percent 28.30 and 23.05% on S1 and S3 media respectively. Also, *P. cornucopiae* on S1 recoded 21.80% while the lower percent was 8.80% and 9.80% for *P. ostreatus* (grey and white) on S2 and S3 media, respectively (Table 5).

Dry Matter and Moisture Content

Table 6 showed different values of dry matter and moisture content for four fresh oyster mushroom harvested from three agricultural substrates namely; S1, S2 and S3. The higher dry matter was 13.46% and 12.81% for fruits of *P. cornucopiae* and *P. ostreatus* (white) on S1 and S3 media respectively, while the lower dry matter was 8.45, 9.93% and 10.07% for *P. salmoneostramineus* on S1and S3 media and *P. cornucopiae* on S2 medium respectively. In general, *P. ostreatus* (white), *P. cornucopiae*, *P. ostreatus* (grey) and *P. salmoneostramineus* recorded percent of dry matter at averages 12.08%, 11.56%, 10.86% and 9.58% respectively.

From other side, the lower moisture content was 86.54% and 87.19% for fruits of *P. cornucopiae* on S1 medium and *P. ostreatus* (white) on S3 medium respectively, while the higher moisture content was 91.55%, 90.07% and 89.93% for *P. salmoneostramineus* on S1 and S3 media and *P. cornucopiae* on S2 medium respectively. In general, *P. ostreatus* (white), *P. cornucopiae*, *P. ostreatus* (grey) and *P. salmoneostramineus* recorded moisture content of dry matter at averages 87.92%, 88.44%, 89.14% and 90.42% respectively.

Table 5. Total crude fibers percent in dry fruiting bodies of oyster mushrooms.

Agro-substrates	*P. ostreatus* (grey)	*P. ostreatus* (white)	*P. cornucopiae* (yellow)	*P. salmoneostramineus* (pink)	LSD (P<0.05)
S1	10.61	10.10	21.80	28.30	0.837
S2	8.80	12.30	17.90	19.90	
S3	10.50	9.80	17.50	23.05	
Mean	9.97	10.73	19.06	23.75	0.483

Legend: S1: Fruiting bodies which grown on wheat straw, **S2**: Fruiting bodies which grown on 70% wheat straw, 20% sawdust and 10% date palm fiber mixture, **S3**: Fruiting bodies which grown on 50% wheat straw, 30% sawdust and 20% date palm fiber mixture.

Table 6. Dry matter and moisture content percent in fresh fruiting bodies of oyster mushrooms.

Agro-substrates	*P. ostreatus* (grey)	*P. ostreatus* (white)	*P. cornucopiae* (yellow)	*P. salmoneostramineus* (pink)	LSD (P<0.05)
S1 (dry matter)	10.91	11.72	13.46	8.45	1.550
S2 (dry matter)	10.76	11.70	10.07	10.37	
S3 (dry matter)	10.92	12.81	11.15	9.93	
Mean of dry matter	10.86	12.08	11.56	9.58	0.895
S1 (moisture)	89.09	88.28	86.54	91.55	1.550
S2 (moisture)	89.24	88.30	89.93	89.63	
S3 (moisture)	89.08	87.19	88.85	90.07	
Mean of moisture content	89.14	87.92	88.44	90.42	0.895

Legend: S1: Fruiting bodies which grown on wheat straw, **S2**: Fruiting bodies which grown on 70% wheat straw, 20% sawdust and 10% date palm fiber mixture, **S3**: Fruiting bodies which grown on 50% wheat straw, 30% sawdust and 20% date palm fiber mixture.

The pH of Fruit Extracts

In Table 7, no recording for any differences for species of oyster mushroom or type of agricultural medium on concentration of hydrogen ion (pH) for aqueous extracts of their dried fruiting bodies. The values of pH were between 5.63-5.67 for this parameter.

DISCUSSION

Generally, oyster mushroom varieties given increasing in protein value for their fruits which cultivated on S2 medium compared with the control (wheat straw), that may be return to increase nitrogen percent and decrease C:N ratio for S2 medium in the substrate compared with the control before mushroom cultivation [31]. Ahmed [32] refereed to this deemed result when mentioned linking protein of mushroom with nitrogen percent of agricultural substrates. This result agrees with the study of Stamets and Chilton [33] who showed that total protein for oyster mushroom was 30.4% based on dry matter. Also, Dunkwal and Jood [34] referred to that oyster mushroom proteins depends on type of agro-substrates.

The high protein content in fruits of mixture media may be return to high nitrogen percent in date palm fibers (6.4%) compared with wheat straw (3.92%) [35]. Thus date palm fibers amended agro-substrates to raise nitrogen percent and to abound O_2 or save an aerobic condition; that agrees with Hassan [35] and Ahmed [32]. Results of total phenol was compatible with other studies; Hassan [35] refereed to amount of total phenols 0.33 mg/kg based on dry matter on wheat straw substrate compared with 0.21 mg/kg on date palm fibers, that recommends to use this mushroom as an antioxidant factor especially when has been harvested from date palm residues substance.

Differences in total carbohydrates percent of oyster mushroom are clear as shown in Table 3. That agrees with many studies such as percent 52.34% on wheat straw substrate [34].

Table 7. Values of pH for extracts of dry fruiting bodies of oyster mushrooms.

Agro-substrates	*P. ostreatus* (grey)	*P. ostreatus* (white)	*P. cornucopiae* (yellow)	*P. salmoneostramineus* (pink)	LSD ($P<0.05$)
S1	5.80	5.70	6.20	5.53	0.062
S2	5.53	5.70	6.20	5.70	
S3	5.57	5.63	6.33	5.70	
Mean	5.63	5.67	6.24	5.64	0.036

Legend: S1: Fruiting bodies which grown on wheat straw, **S2**: Fruiting bodies which grown on 70% wheat straw, 20% sawdust and 10% date palm fiber mixture, **S3**: Fruiting bodies which grown on 50% wheat straw, 30% sawdust and 20% date palm fiber mixture.

Carbon source is important for increasing total carbohydrates in mushroom fruits' through increasing of production of lignolytic enzymes [36]. Also, Tshinyangu [37] refereed to that the nutritional value of oyster mushroom greatly differed according to chemical composition of agro-substrates. The differences of carbohydrate, protein and total phenol for all oyster mushroom species may be return to the big diversity in biochemical properties of these species [24,38].

The reason of increasing ash percent in fruits of S3 substrate compared with the control returns to the high content of mineral elements in samples [31]. These results agree with Dunkwal and Jood [34], they recorded ash at percent 8.89% for oyster mushroom on wheat straw substrate, while Rampinelli et al. [39] recorded ash percent between 7.4-6.3%. Species of oyster mushroom differ in crude fibers content according to their genetic characteristics and compositin of nutrients in substrates [40]. Also, these results agree with Dunkwal and Jood [34] and Rampinelli et al. [39], they recorded crude fiber of oyster mushroom 11.59% and 12.7-27.4% respectively.

Ahmed [32] refereed to that the oyster mushroom's fruits cultivated on mixture substrates was richer in dry matter and crude fibers than on only one substrate, due to low nutrients in last formula. Moisture content of edible mushrooms changes according to harvesting conditions and type of agro-substrates [41]. Hassan [35] recorded dry matter for *P. ostreatus* 12.42% on wheat straw and 11.57% on date palm substrate, while its fresh fruits had moisture content reached to 91% [33]. Finally, the agro-substrate that composed from more than one carbon source is richer than the substrate that composed from one substrate, chemically.

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