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Journal of Agricultural Sciences
Journal homepage:
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Effect of Various Agro-Residues on Nutritive Value of *Pleurotus eryngii* (DC. ex Fr.) Quel. var. *ferulae* Lanzi

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ARTICLE INFO

Research Article — Crop Production

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Received: 15 December 2008, Received in revised form: 05 April 2010, Accepted: 23 May 2010

ABSTRACT

In this study, the effect of various compost medium on the nutritive value of *P. eryngii* var. *ferulae* were determined. Dry matter, moisture, crude ash, protein, fat and organic matter were determined as 91.7-92.7, 7.3-8.3, 5.4-6.1, 8.5-19.7, 2.5-4.1 and 85.8-86.9% of air-dried weight, respectively. There were no significant differences in crude ash and organic matter content for *P. eryngii* var. *ferulae* grown on various agro-residues. Crude protein and fat contents varied significantly, the lowest protein content was obtained in natural wild sample (8.5%), whereas the highest were obtained in WS + 10% RB (18.0%), WS-CS (1:1) + 10% RB (18.5%), WS + 20% RB (18.9%) and WS-CS (1:1) + 20% RB (19.7%). Minimum crude fat content was 2.5% in WS-CS (1:1), maximum was 3.9-4.1% in WS + 10% RB, WS + 20% RB, WS-CS (1:1) + 10% RB and WS-CS (1:1) + 20% RB. Mineral contents varied significantly, their contents were determined to be 14.3-22.6 for K, 0.12-0.70 for Ca and 0.1-0.3 for mg g⁻¹ Na as macro elements, 519.5-1142.3 for Fe, 33.5-102.5 for Zn, 41.6-64.6 for Mn, 25.8-48.5 for Cu and 1.3-2.3 for mg kg⁻¹ Cr as micro elements. Pb, Co, Ni and Cd concentrations were under the detection limit of the method used.

Keywords: Agro-residues; Crude fat; Crude protein; Element; *P. eryngii* var. *ferulae*

Değişik Tarımsal Artıkların *Pleurotus eryngii* (DC. ex Fr.) Quel. var. *ferulae* Lanzi'nin Besin Değerleri Üzerine Etkisi

ESER BİLGİSİ

Araştırma Makalesi — Bitkisel Üretim

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Geliş tarihi: 15 Aralık 2008, Düzeltmelerin gelişi: 05 Nisan 2010, Kabul: 23 Mayıs 2010

ÖZET

Bu çalışmada; değişik compost ortamlarının *P. eryngii* var. *ferulae*'nin besin değerleri üzerine etkileri belirlenmiştir. Kuru madde, nem, ham kül, ham protein, ham yağ ve organik madde içerikleri; kuru ağırlığın %91.7-92.7, %7.3-8.3, %5.4-6.1, %8.5-19.7, %2.5-4.1 ve %85.8-86.9 olarak bulunmuştur. Değişik tarımsal artıklar üzerinde yetiştirilen *P. eryngii* var. *ferulae*'nin; ham kül ve organik madde içeriklerinde istatistiksel olarak önemli bir fark bulunmamıştır. Ham protein ve yağ içeriklerinin değişken olduğu, en düşük ham protein içeriği; doğa'dan sağlanan yabancı örnekte (% 8.5) elde edilirken, en yüksek ise; BS + %10 PK (%18.0), BS + %20 PK (%18.9), BS-PS (1:1) + %10 PK (%18.5) ve BS-PS (1:1) + %20 PK (%19.7) ortamlarında elde edilmiştir. Minimum ham yağ içeriği; BS-PK (1:1) ortamında %2.5, maksimum ise BS + %10 PK, BS + %20 PK, BS-PS (1:1) + %10 PK ve BS-PS (1:1) + %20 PK'de

%3.9-4.1'dir. Element içeriklerinin değişken olduğu ve 14.3-22.6 K, 0.12-0.70 Ca ve 0.1-0.3 mg kg⁻¹ Na gibi makro elementler, 519.5-1142.3 Fe, 33.5-102.5 Zn, 41.6-64.6 Mn, 25.8-48.5 Cu ve 1.3-2.3 mg kg⁻¹ Cr gibi mikro elementler olarak belirlenmiştir. Ayrıca; Pb, Co, Ni ve Cd konsantrasyonları kullanılan metodun belirleme limitinin altında bulunmuştur.

Anahtar sözcükler: Tarımsal artıklar; Ham yağ; Ham protein; Element; *P. eryngii* var. *ferulae*

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1. Introduction

More than 2000 species of mushrooms exist in nature, but approximately 22 species are intensively cultivated (Manzi et al 2001). In most countries, there is a well-established consumer acceptance for cultivated mushrooms such as *Agaricus bisporus*, *Lentinus edodes*, *Pleurotus* spp., *Volvariella volvacea*, *Auricularia* spp. (Diez & Alvarez 2001).

Cultivation of *Pleurotus* spp. has become a large-scale production in the last thirty years. In the world's mushroom production *Pleurotus* spp. are in the third place after the white button mushroom and shiitake. Production techniques for these basidiomycetes are well developed, and are relatively simple, compared with those used for the most commonly cultivated mushroom (Ragunathan & Swaminathan 2003). They may be cultivated on a large number of substrates, according to local availability in different regions of the world. The majority of these substrates has been used as animal feed. However, their low digestibility, low protein content and high lignin content render them unpopular and unacceptable (Cohen et al 2002). Mushroom culture is a biotechnological process that recycles lignocellulosic wastes, since these are converted to a food for human. Its popularity has been increasing due to its ease of cultivation, high yield potential and high nutritional value (Mau et al 1998; Manzi et al 1999; Guo et al 2007). This type of biotechnological approach results in the conversion of agricultural wastes into food of high fructification and nutritive value or into good quality fodder by enriching the waste protein content and by improving their digestibility as stated by Philipposis et al (2001) and Cohen et al (2002).

The purpose of this study is to determine effects of various composts on the nutritive value of *P. eryngii* var. *ferulae*.

2. Materials and Methods

2.1. Obtained of mushroom samples

The mushroom samples used in this study were obtained from the previous culture work (Kırbağ & Akyüz 2008).

Wheat straw (WS) and mixture of wheat straw-cotton stalk (CS) at a ratio of 1:1 were used in preparing two different types of compost. All composts were supplemented with rice bran (RB) at a rate of 10% or 20%, therefore, 6 types of compost were prepared. The mushroom fructification obtained after culture were harvested in sterile conditions and labeled. The mushroom samples were dried at room temperature for 15 days and then stored in loosed bags. These samples were used in this study.

2.2. Proximate analysis

The proximate composition of *P. eryngii* var. *ferulae*, including moisture, dry matter, crude protein, crude fat, crude ash and organic matter, were determined according to AOAC (1990) methods. Total nitrogen (N) was determined by the Kjeldahl method. Crude protein was calculated as N x 6.25 (Diez & Alvarez 2001). Crude fat was determined using the soxhlet extraction method with ether as solvent and total ash by incineration at 550°C. Organic matter was calculated as % dry matter - % ash.

2.3. Element analysis

Each sample of air-dried mushroom was dried at 105°C overnight and crushed in a mortar and pestle. Digestion of mushroom samples was performed using mixture of HNO₃: H₂SO₄: H₂O₂ (10:1:1, 12 ml for 1 g sample) and heating 100°C for about 10-15 min. After cooling, 50 ml deionized water was added and filtered. All sample solutions were clear. While amounts of Fe, Zn, Mn, Cu, Cr, Cd, Co, Ni

and Pb were determined by atomic absorption spectrometer (Perkin-Elmer, model: 370 made by: The Perkin-Elmer Corporation Norwalk Connecticut, USA), those of K, Ca and Na were performed by atomic emission spectrometer (Eppendorf Geratebau, Netheler + HINZ GMBH Hamburg, GERMANY) (Anonymous 1990).

2.4. Statistical analysis

All data collected were analysed by the analysis of variance. The least significant differences among means were determined through Tukey's Honest Significant Difference (HSD) multiple comparison test at 0.05 level, with Statistical Package for the Social Sciences (SPSS) 13.0 computer program (SPSS, Chicago, Illinois, USA). After multiple comparisons, the means were interpreted as follows: Tables were followed with different small letters "a-f" based on their values and statistical differences. Means followed by the same letter (s) are not significantly different but means followed by different letter(s) are significantly different at 0.05. The experiments were repeated 3 times (n=3).

3. Results and Discussion

There were, however, no significant differences in crude ash and organic matter contents for *P. eryngii* var. *ferulae* grown on various agro-residues (Table 1).

Crude ash content ranged from 5.4-6.1%, and organic matter ranged from 85.8-86.9% see in Table 1. The reported ash contents were 4.96% in *P. eryngii* var. *ferulae* (Guo et al 2007), 5.15-7.21% in *P. eryngii* (Mau et al 1998), 9.16-10.55% in *P. eryngii* and 8.61% in *P. eryngii* var. *ferulae* (Manzi et al 1999). Ash contents are similar to that reported in similar studies (Mau et al 1998), lower than that reported earlier (Manzi et al 1999), and higher than previously reported (Guo et al (2007).

The lowest crude protein content was found to be 8.5% on natural wild sample, while the highest were 18.0% on WS + 10% RB, 18.5% on WS-CS (1:1) + 10% RB, 18.9% on WS + 20% RB and 19.7% on WS-CS (1:1) + 20% RB in Table 1. In order to enriched the protein content of *P. eryngii* var. *ferulae*, rice bran could be combined with WS and WS-CS (1:1). Adding 10% RB to compost led

to an increase in protein contents of mushroom for WS and WS-CS (Table 1). Adding 10% RB to WS and WS-CS (1:1) increased crude protein content of mushroom, but in respect of 10% RB, 20% RB addition rate was not found important. The crude protein contents of *P. eryngii* var. *ferulae* which was obtained from WS + 10% RB, WS + 20% RB, WS-CS (1:1) + 10% RB and WS-CS (1:1) + 20% RB were observed to be very similar statistically. The reported crude protein contents were 30.3% in *P. eryngii* var. *ferulae* (Guo et al 2007), 20.71-22.15% in *P. eryngii* (Mau et al 1998), 22.74-22.89% in *P. eryngii* and 23.21-25.41% in *P. eryngii* var. *ferulae* (Manzi et al 1999). Protein contents of *P. eryngii* var. *ferulae* are lower than those reported earlier (Mau et al 1998; Manzi et al 1999; Guo et al 2007). The chemical composition of the substrates used in cultivation has a direct effect on the chemical composition of the fruiting bodies (Table 1).

Minimum crude fat content was 2.5% on WS-CS (1:1) and maximum were 3.9% on WS + 10% RB, WS-CS (1:1) + 10% RB and WS-CS (1:1) + 20% RB, and 4.1% on WS + 20% RB see in Table 1. With the addition of 10% RB to WS and WS-CS (1:1), crude fat content of mushroom was increased, but in respect of 10% RB, 20% RB addition rate was not found important statistically. The crude fat contents of *P. eryngii* var. *ferulae* which was obtained from WS + 10% RB, WS + 20% RB, WS-CS (1:1) + 10% RB and WS-CS (1:1) + 20% RB were observed to be very similar statistically. The reported crude fat contents were 5.71% in *P. eryngii* var. *ferulae* (Guo et al 2007), 1.57-1.81% in *P. eryngii* (Mau et al 1998). The levels of crude fat determined in *P. eryngii* var. *ferulae* are lower than that in previous report (Guo et al 2007), and higher than previously reported (Mau et al 1998). The differences between the values obtained might arise from the biological structure of substrat and additive materials (Table 1).

The lowest potassium contents were found to be 14.3 mg g⁻¹ on WS + 10% RB, 15.3 mg g⁻¹ on WS, while the highest were 21.5 mg g⁻¹ on WS-CS (1:1), 21.6 mg g⁻¹ on WS-CS (1:1) + 10% RB, and 22.6 mg g⁻¹ on natural wild sample as seen in Table 2. No statistical difference was found with the potassium rate of mushroom samples which was

Table 1-Nutritional composition of *P. eryngii* var. *ferulae* grown on various agro-wastes (% , air-dried basis)Çizelge 1-Değişik tarımsal atıklar üzerinde yetiştirilen *P. eryngii* var. *ferulae*'nin besin bileşimleri (% , havada kuru esasında)

Material	Dry Matter	Crude Ash	Crude Protein	Crude Fat	Organic Matter
WS	92.4±0.4	5.4±0.3	12.9±0.9 ^b	2.9±0.05 ^b	86.9±0.1
WS + 10% RB	91.9±0.4	5.9±0.1	18.0±0.3 ^d	3.9±0.04 ^c	85.9±0.5
WS + 20% RB	92.1±0.4	5.7±0.1	18.9±0.2 ^d	4.1±0.04 ^c	86.4±0.6
WS-CS (1:1)	92.7±0.8	5.8±0.2	17.6±0.8 ^c	2.5±0.08 ^a	86.9±1.1
WS-CS (1:1) + 10% RB	91.7±0.5	5.9±0.1	18.5±1.0 ^d	3.9±0.05 ^c	85.8±0.6
WS-CS (1:1) + 20% RB	92.5±0.3	6.1±0.1	19.7±0.2 ^d	3.9±0.01 ^c	86.5±0.2
Natural wild sample	91.8±0.4	5.8±0.2	8.5±0.2 ^a	2.9±0.07 ^b	86.1±0.6
<i>P values</i>		0.076	<0.001	<0.001	0.392

Each value is expressed as mean ± SD of three replicate analyses (n=3)

Values with different small letters in the same column are significantly different at the level of 0.05 ($P < 0.05$)

Wheat straw (WS), cotton stalk (CS), rice bran (RB), Natural wild sample: Icme-Elazığ

Table 2-Element contents of *P. eryngii* var. *ferulae* grown on various agro-wastes (air-dried basis)Çizelge 2-Değişik tarımsal atıklar üzerinde yetiştirilen *P. eryngii* var. *ferulae*'nin element içerikleri (havada kuru esasında)

Material	Macro elements			Micro elements (mg kg ⁻¹)				
	K (mg g ⁻¹)	Ca (mg g ⁻¹)	Na (mg kg ⁻¹)	Fe	Zn	Mn	Cu	Cr
WS	15.3±0.3 ^{ab}	0.51±0.01 ^c	100.0±1.2 ^a	620.7±2.7 ^c	33.5±1.5 ^a	52.2±1.2 ^d	34.1±0.3 ^b	2.1±0.04 ^a
WS + 10% RB	15.9±0.3 ^b	0.59±0.02 ^d	174.1±4.0 ^c	521.1±4.9 ^a	40.5±1.5 ^b	50.0±1.0 ^{cd}	34.0±0.9 ^b	1.7±0.17 ^a
WS + 20% RB	14.3±0.3 ^a	0.12±0.02 ^a	152.5±2.5 ^b	589.3±1.4 ^c	102.5±4.5 ^d	47.1±1.0 ^b	41.4±0.7 ^c	1.6±0.02 ^a
WS-CS (1:1)	21.5±0.9 ^d	0.30±0.02 ^b	307.5±5.6 ^f	540.3±2.0 ^b	53.5±1.5 ^c	64.6±1.8 ^c	48.5±0.2 ^d	2.0±0.04 ^a
WS-CS (1:1) + 10% RB	21.6±0.4 ^d	0.70±0.03 ^e	227.8±2.5 ^d	519.5±5.5 ^a	50.5±2.1 ^c	41.6±1.5 ^a	40.9±1.5 ^c	1.3±0.06 ^a
WS-CS (1:1) + 20% RB	18.8±0.8 ^c	0.17±0.02 ^a	240.0±5.0 ^e	607.5±7.5 ^d	53.0±1.4 ^c	47.5±3.5 ^b	40.7±1.8 ^c	2.3±0.13 ^a
Natural wild sample	22.6±0.7 ^d	0.57±0.02 ^d	168.5±4.9 ^c	1142.3±5.5 ^f	43.5±3.5 ^b	49.9±2.8 ^c	25.8±1.3 ^a	- ^b
<i>P values</i>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Each value is expressed as mean ± SD of three replicate analyses (n=3),

Values with different small letters in the same column are significantly different at the level of 0.05 ($P < 0.05$)

Wheat straw (WS), cotton stalk (CS), Rice bran (RB), Natural wild sample: Icme-Elazığ

Pb, Co, Ni and Cd: analyzed, but not detected (the concentrations were under the detection limit of the method used) The limits are 5-25, 1-5, 1-5 and 0.4-2 mg kg⁻¹, respectively

obtained from WS and WS-CS (1:1) + 20% RB, also WS and WS-CS (1:1) + 20% RB. Besides, difference in WS-CS (1:1), WS-CS (1:1) + 10% RB and natural wild sample was not considered statistically important (Table 2). The reported potassium contents were 16.2 mg g⁻¹ in *P. eryngii* var. *ferulae* (Guo et al 2007), 26.1 mg g⁻¹ in *P. eryngii* var. *ferulae* and 30.9-40.5 mg g⁻¹ in *P. eryngii* (Manzi et al 1999). The levels of potassium on WS + 10% RB and WS are higher than that in previous report (Guo et al 2007), and levels on WS-CS (1:1), WS-CS (1:1) + 10% RB and natural wild sample are lower than previously reported (Manzi et al 1999). The differences between the values obtained might arise from the biological structure of substrat and additive material (Table 2).

The highest calcium content was 0.70 mg g⁻¹ on WS-CS (1:1) + 10% RB, whereas the lowest were 0.12 mg g⁻¹ on WS + 20% RB and 0.17 mg g⁻¹ on WS-CS (1:1) + 20% RB (Table 2). Addition of 10% RB to WS and WS-CS (1:1) medium increased the calcium level, but in the addition rate 20% RB was decrease in respective of 10% addition rate. No statistical difference was found with the calcium content of mushroom samples which was obtained from WS + 10% RB and natural wild sample, also WS + 20% RB and WS-CS (1:1) + 20% RB, but the difference was considered important in the other trial groups (Table 2). The reported calcium contents were 28.4 mg g⁻¹ in *P. eryngii* var. *ferulae* and 33.7-35.3 mg g⁻¹ in *P. eryngii* (Manzi et al 1999), 69 mg kg⁻¹ in *P. eryngii* var. *ferulae* (Gong

et al 2003), 96.8 mg kg⁻¹ in *P. eryngii* var. *ferulae* (Shi & Shao 2003) and 0.23 mg g⁻¹ in *P. eryngii* var. *ferulae* (Guo et al 2007). The level of calcium on WS-CS (1:1) + 10% RB is higher than that in previous report (Manzi et al 1999; Gong et al 2003; Shi & Shao 2003; Guo et al 2007), and levels on WS + 20% RB and WS-CS (1:1) + 20% RB are lower than previously reported (Manzi et al 1999; Guo et al 2007). According to data obtained, the main reason for different results is due to the use of different material in culture medium (Table 2).

Minimum sodium content was 0.1 mg g⁻¹ on WS, and maximum was 0.3 mg g⁻¹ on WS-CS (1:1) as seen in Table 2. Addition of 10% RB to WS and WS-CS (1:1) increased the sodium level, but in the addition rate 20% RB was variable in respective of 10% addition rate. The reported sodium contents were 0.44 mg g⁻¹ in *P. eryngii* var. *ferulae* and 0.50-0.76 mg g⁻¹ in *P. eryngii* (Manzi et al 1999). Sodium contents of *P. eryngii* var. *ferulae* which was obtained from various compost medium are low compared to an earlier published report (Manzi et al 1999).

The iron concentration was high on natural wild sample (1142.3 mg kg⁻¹) and ranged from 100.0 to 307.5 mg kg⁻¹ (Table 2). Iron content of *P. eryngii* var. *ferulae* which was obtained from natural wild sample was found higher than that in culture medium. Adding 10% RB to WS and WS-CS (1:1) decreased iron level of mushroom, but with 20% RB addition rate increased it in respect of 10% RB addition rate (Table 2). The reported iron content were 33 mg kg⁻¹ in *P. eryngii* var. *ferulae* (Gong et al 2003), 887 mg kg⁻¹ in *P. eryngii* var. *ferulae* (Shi & Shao 2003) and 0.07 mg g⁻¹ in *P. eryngii* var. *ferulae* (Guo et al 2007). Iron contents of *P. eryngii* var. *ferulae* which was obtained from various compost medium are higher compared to an earlier published report (Gong et al 2003; Guo et al 2007), but that data (Shi & Shao 2003) is different from the data in our work (from 100.0 to 307.5 mg kg⁻¹). This difference probably was due to the use of mushroom samples obtained from different growing media.

Maximum zinc content was 102.5 mg kg⁻¹ on WS + 20% RB, while the lowest were 40.5 mg kg⁻¹ on WS + 10% RB and 43.5 mg kg⁻¹ on natural wild

samples seen in Table 2. Adding 10% and 20% RB to WS increased zinc level, but in WS-CS (1:1) was stable. The reported zinc content were 78 mg kg⁻¹ in *P. eryngii* var. *ferulae* (Gong et al 2003), 190 mg kg⁻¹ in *P. eryngii* var. *ferulae* (Shi & Shao 2003) and 0.08 mg g⁻¹ in *P. eryngii* var. *ferulae* (Guo et al 2007). The level of zinc on WS + 20% RB is higher than that in previous report (Gong et al 2003; Guo et al 2007), and levels on WS, WS + 10% RB, WS-CS (1:1), WS-CS (1:1) + 10% RB, WS-CS (1:1) + 20% RB and natural wild sample are lower than previously reported (Shi & Shao 2003; Guo et al 2007). The differences between the values obtained might arise from the biological structure of substrat and additive material.

The highest manganese content was 64.6 mg kg⁻¹ in WS-CS (1:1), the lowest was 41.6 mg kg⁻¹ in WS-CS (1:1) + 10% RB (Table 2). Adding 10% RB to WS did not change manganese content of mushroom statistically, but in 20% RB addition rate change similar to 10% RB was found. On the other hand, no statistical difference was found for the manganese rate of mushroom samples which was obtained from WS + 20% RB and WS-CS (1:1) + 20% RB. The reported manganese content was 143 mg kg⁻¹ in *P. eryngii* (Dogan et al 2006). The level of manganese content of *P. eryngii* var. *ferulae* which was obtained from various compost medium is lower compared to an earlier published report (Dogan et al 2006).

The lowest and highest copper values were found on natural wild sample (25.8 mg kg⁻¹) and WS-CS (1:1) (48.5 mg kg⁻¹) as seen in Table 2. Adding 10% RB to WS had no significant effect, but 20%RB level increased copper content of the mushroom. Contrary to WS, both 10 and 20% RB addition to WS-CS (1:1) material reduced mushroom copper content. Besides, the lowest copper level was found in natural wild sample (Table 2). The reported copper values for *P. eryngii* was 16.5 mg kg⁻¹ (Dogan et al 2006). Manganese contents of *P. eryngii* var. *ferulae* which was obtained from various compost medium are higher compared to an earlier published report (Dogan et al 2006). The differences between reported and obtained values might arise from the biological structure of substrat and additive material (Table 2).

When compared with other wastes, the chromium concentration ($1.3\text{--}2.3\text{ mg kg}^{-1}$) was not significantly affected by various composts (Table 2). In natural wild samples, chromium had not been detected. The reported chromium content was 46.7 mg kg^{-1} in *P. eryngii* (Dogan et al 2006). Chromium contents of *P. eryngii* var. *ferulae* harvested from various compost medium in this study are lower compared to an earlier published report (Dogan et al 2006). This difference probably was due to the use of mushroom samples obtained from different growing media.

Other information on toxic metals, such as lead, cobalt, nickel and cadmium in this study has been studied, and those heavy metal levels were not detected. Hence, those value are relatively compared to previously published report (Dogan et al 2006). The uptake of metal ions in mushrooms is many respects different from plants; the concentration of metals depends on mushroom species, their ecosystems and soil (Dogan et al 2006).

4. Conclusion

In this study, it was found that products including low lipid and high protein can be produced using various plants materials. Crude protein contents of *P. eryngii* var. *ferulae* obtained from WS + 10% RB, WS + 20% RB, WS-CS (1:1) + 10% RB and WS-CS (1:1) + 20% RB were higher than those of WS and WS-CS. Natural wild sample had lowest crude protein content. Element contents of *P. eryngii* var. *ferulae*, in different manner, were also affected by WS, WS-CS and RB addition. However, heavy metals have not been detected in mushroom samples. Mentioned plant materials and additive matter had proved to be a good substrate for the high protein content of *P. eryngii* var. *ferulae*. Mixtures of various agro-residues in a ratio of 1:1 should be used and combined with rice bran to produce nutritionally enriched *P. eryngii* var. *ferulae*.

Acknowledgements

This study was financially supported by Firat University (Project No: FÜBAP-1446). The authors also wish to thank the reviewers for their valuable comments.

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