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Determination of the Effects of Different Tree Logs on Yield and Some Quality Properties in Oyster Mushroom [*Pleurotus ostreatus* (Jacq.) P. Kumm.]

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Abstract

Oyster mushroom (Pleurotus spp.), which is the second most cultivated mushroom species in the world after the cultivated mushroom (Agaricus bisporus), can be grown at lower temperatures than other species and needs less specific ecological factors, making it easier to cultivate. In the current study, oyster mushroom (Pleurotus ostreatus) was grown in substrates prepared by using logs of beech (Fagus spp.), chestnut (Quercus spp.), poplar (Populus spp.), and linden (Tilia spp.) trees. In this context, the study was carried out in the mushroom production room of Canakkale Onsekiz Mart University, Faculty of Agriculture, Department of Horticulture. In the study, yield, fruit characteristics, protein amount, soluble solids, pH, TETA (Titratable acidity) and flavor value were determined. It was observed that Pleurotus ostreatus micelles did not spread on the linden logs during the incubation stage. When other logs were evaluated, it was determined that beech, poplar and chestnut logs were more suitable for oyster mushroom cultivation in terms of yield, respectively. While the lowest protein value was obtained in the beech log substrate, the highest protein value was obtained in the chestnut log substrate. In terms of external appearance, it can be said that beech and poplar logs have similar and more suitable values. In terms of the study results, beech medium can be recommended for cultivation with the aim of high yield, while chestnut medium can be recommended for cultivation with the aim of high protein value.

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Farklı Ağaç Kütüklerinin Kayın Mantarında [*Pleurotus ostreatus* (Jacq.) P. Kumm.] Verim ve Bazı Kalite Özelliklerine Etkilerinin Belirlenmesi

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Öz

Dünya'da kültür mantarından (*Agaricus bisporus*) sonra ikinci en çok yetiştirilen mantar türü olan Kayın mantarının (*Pleurotus spp*.) diğer türlere göre düşük veya yüksek sıcaklıklara ve diğer ekolojik faktörlere daha toleranslı olması daha kolay kültüre alınabilmesini sağlamaktadır. Bu çalışmada kayın (*Fagus spp*.), kestane (*Quercus spp*.), kavak (*Populus spp*.) ve ıhlamur (*Tilia spp*.) ağaçlarının kütükleri kullanılarak hazırlanan besi ortamlarında kayın mantarı (Pleurotus ostreatus) yetiştirilmiştir. Bu kapsamda çalışma Çanakkale Onsekiz Mart Üniversitesi, Ziraat Fakültesi, Bahçe Bitkileri Bölümüne ait olan mantar üretim odasında yürütülmüştür. Çalışmada verim, meyve özellikleri, protein miktarı, SÇKM, pH, TETA (Titre edilebilir asitlik) ve lezzet değeri belirlenmiştir. İnkübasyon aşamasında *Pleurotus ostreatus* misellerinin ıhlamur kütüklerini sarmadığı görülmüştür. Diğer kütükler değerlendirildiğinde verim açısından sırası ile kayın, kavak, kestane kütüklerinin kayın mantarı yetiştiriciliğine daha uygun olduğu belirlenmiştir. En düşük protein değeri kayın kütüğü ortamında elde edilirken, en yüksek protein değeri kestane kütüğü ortamından elde edilmiştir. Dış görünüm açısından ise kayın ve kavak kütüklerinin benzer ve daha uygun değerler aldığı söylenebilir. Çalışma sonuçları açısından yüksek verim amacı ile yapılan bir yetiştiricilikte kayın ortamı önerilebilir iken yüksek protein değeri amacı ile yapılan bir yetiştiricilikte kestane ortamı önerilebilir.

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Introduction

The fact that mushroom cultivation can be done by using agricultural residues as a substrate without requiring high costs shows that it is an economically significant issue. Oyster mushroom, also known as beech mushroom, grows mostly on beech trees and their remains in nature. The commercial cultivation of oyster mushroom (*Pleurotus ostreatus*) is generally done using different substrate mixtures. Freshly cut logs are used in log cultivation. This method is used by growers, but the mushrooms are grown in nature on logs. This situation causes the logs to be exposed to various rodent damage and unsuitable external conditions. Mushroom cultivation is mostly done by using partially rotted agricultural and various materials called compost as a nutrient substrate. Numerous studies have been carried out using various compost mixtures, especially in terms of evaluating the materials that are occur as a result of various agricultural and industrial processes and have nutritional value in terms of mushroom cultivation. Mushroom cultivation in compost requires more technical knowledge, especially in terms of preparation, disinfection and growing stages, compared to log cultivation. On the other hand, logs cultivation are not very well known, although it requires less technical knowledge. In addition, in log cultivation, yields can be obtained from logs for many years. If the same log is re-sowed at the end of the year, yield increases and production can be done without supplying new substrate for 2 or 3 years. Besides, there are a limited number of studies on different tree logs, including yield characteristics of oyster mushroom as well as various quality characteristics.

In a study (Martinez-Carrera, 1998), it's mentioned that the first large amount of production of *Pleurotus* spp. was carried out by growing it on logs in Hungary in 1969; after it was understood that lignocellulosic by-products originated from agriculture or forestry were suitable as nutrient substrate, many varieties were started to be grown in the world. Sanchez (2010) mentioned that *P. ostreatus* mushrooms can be grown in less controlled conditions; diseases and pests often do not cause damage to this mushroom; and this mushroom species can be cultivated in an easier and cheaper way. In the previous study (Doğan, 2019), oyster mushrooms (*P. ostreatus*) were grown on the logs of beech and poplar trees. In their study, logs with a diameter of 20-30 cm were first cut to a length of about 30-50 cm and 100 g of mycelium

planted in each log. In the first year of their study, they obtained a yield of 69.917 kg from 32 beech logs and 8.535 kg from 30 poplar logs. In another study (Pekşen, 2013) 100 g mycelin was inoculated onto poplar tree stumps with a diameter of 30-40 cm and a length of 40-50 cm in outdoor cultivation. As a result of their studies, they reported that yield can be obtained for 3-5 years; the total yield during this period is 20-30% of the log weight and 2-5 kg yield / log is taken in 1 year.

It was reported that shiitake mushrooms (*Lentinula edodes*) can be grown on oak, wild chestnut, hornbeam, beech, poplar and chestnut tree stumps for 5-6 years (Boztok and Erkip, 2002), lion's mane mushroom (*Hericium* sp.) can be grown on beech tree stump for 6 years (Grace and Mudge, 2015).

Tisdale et al. (2006) were grown oyster mushroom (*Pleurotus ostreatus*) on substrates consisting of small wood chips obtained from different trees (*Falcataria moluccana* (Miquel) Barneby & Grimes, *Casuarina equisetifolia*, *Eucalyptus grandis*, *Psidium cattleianum* Sabine, *Trema orientalis* L. Blume) and wheat bran. They determined that *P. ostreatus* gave more yield on the substrate obtained from *C. equisetifolia*, *T. orientalis*, *F. moluccana* tree species than the substrate obtained from other tree species in their study.

In study conducted by (Kurt, 2008), it was observed that different media mixtures (vine pruning residue, 2 vine pruning residues + bran, wheat straw, 2 wheat straw + bran, paddy stalk, 2 paddy stalk + bran, sesame stalk, 2 sesame stalk + bran, 2 sawdust + bran + control) had significant effects on yield in two different oyster mushroom species (*P. ostreatus*, *P. sajor-caju*). The highest yield was seen in 2 wheat straw + bran substrate (300.24 g/per kg), the lowest yield was determined in wheat straw substrate (158.88 g/per kg). When the protein amounts in *P. ostreatus* species were examined, they determined that the lowest protein amount was 16% in the wheat straw substrate, and the highest protein amount was 30.46% in the 2 vine pruning residue + bran substrate.

Onyeka et al. (2017) cultivated the *P. ostreatus* using different substrates consisting of sawdust + corn waste + $CaCO_3$, sawdust + rice bran + $CaCO_3$, sawdust + banana leaf, sawdust + cassava (*Manihot esculenta*) peel, and cassava peel. Sawdust + cassava peel substrate was the substrate with the highest yield (463 g/kg). The second highest yield was obtained from sawdust + rice bran + $CaCO_3$. The substrate with the lowest efficiency was sawdust + corn waste + $CaCO_3$ (200 g/kg).

Protein amounts of *P. ostreatus*, *P. florida*, *P. sajor-caju* species grown in wheat straw substrate were between 28.9±0.4-36.4±0.1%, crude fat amounts were 0.5±0.3 -3.7±0.1%, crude carbohydrate amounts were between 38.5±0.2-44.0±0.7% (Kırbağ and Korkmaz, 2014). In study (Akyüz et al., 2021), which they cultivated *P. ostreatus* on wheat straw, alfalfa straw (*Medicago sativa*), wheat straw + alfalfa straw (1:1), alfalfa straw + *Prangos pabularia* plant (1:1); the crude protein amount was between 25.2-33.3 and they determined the amount of crude fat between 1.7-2.5. When the studies (Kırbağ and Korkmaz, 2014; Akyüz et al, 2021) are evaluated, it is seen that the *Pleurotus* species have high nutritional protein content and low fat content, and they are a good dietary product in this regard. In a study (Avcı, 2015), the protein values of oyster mushroom (*P. ostreatus*) grown in different substrates varied between 31.02% and 11.91%.

Hoa et al. (2015) studied the effects of different substrate (100% sawdust-acacia tree, 100% sugarcane waste, 50% sawdust + 50% sugarcane waste, 80% sawdust + 20% sugarcane waste, 100% corncob, 50% sawdust + 50% corncob, 80% sawdust + 20%corncob) on growth, yield and nutritional composition of two oyster mushroom species (*P. ostreatus*, *P. cystidiosus*) and they determined the highest yield in 100% corncob substrate in *Pleurotus ostreatus*. In their study (Hoa et al., 2015), the highest protein content was obtained from 100% corn cob substrate (29.70% for *P. ostreatus*, 24.54% for *P. cystidiosus*)

in both species, while the protein amounts were 19.52% for *P. ostreatus* and 15.68% for *Pleurotus cystidiosus* in sawdust substrate obtained from acacia tree.

In cultivation of oyster (*P. ostreatus*) mushroom 100% olive pulp, 75% oak sawdust + 25% olive pulp, 50% oak sawdust + 50% olive pulp, 25% oak sawdust + 75% olive pulp, 100% yarn factory fiber refuse, % 75 oak sawdust + 25% yarn factory fiber refuse, 50% oak sawdust + 50% yarn factory fiber refuse, 25% oak sawdust + 75% yarn factory fiber refuse substrates were used (Sözbir, 2021). As a result of their study (Sözbir, 2021), the highest yield and cap diameter values were obtained from 75% oak sawdust + 25% fiber refuse substrate; the biological activity rates of the substrates were varied between 1.43 (50% oak sawdust + 50% olive pulp substrate) and 14.05 (75% oak sawdust + 25% fiber refuse substrate).

Mushrooms are an important nutritional source, especially with their high protein and low fat content. In addition, mushroom production can be done without requiring a large investment and especially by using the materials resulting from agricultural production. However, mushroom production is a business that requires technical knowledge and labor. The aim of the study is to determine the yield and quality characteristics of *Pleurotus ostreatus* species in substrates consisting of various tree stumps. Another aim of the study is to give information about the log cultivation method, which is less technical, easy built method compared to compost farming.

Material and Method

The seed mycelium of the oyster mushroom (*P. ostreatus*) planned to be grown in the study was obtained from a commercial establishment. The logs used as a substrate in the study were obtained from Çanakkale Provincial Management of Agriculture and Forestry. Substrate used in mushroom production were beech (*Fagus* spp.), chestnut (*Castanea* spp.), poplar (*Populus* spp.), linden (*Tilia* spp.) logs.

The following substrate were used in the study:

1- Poplar substrate,

2- Beech substrate,

3- Linden substrate,

4- Chestnut substrate.

Preparation of substrates

Freshly cut logs with a weight of 9.5 kg to be used in mushroom production were cut at an average of one quarter of the height for mycelium cultivation and divided into two, mycelium fed with sawdust was planted on the upper part of the large log and moistened by spraying with water. After this process, the small log was placed on the part where the mycelium was planted. Mycelial inoculation into the substrate was carried out by inoculating micelle (up to 1% by weight of the substrate) into the substrate. The entire log was moistened by spraying, and the edges of the junction section of the two logs where the mycelium was planted were taped from the outside with duct tape. The logs, which were moistened by re-spraying, were placed in black plastic garbage bags, tightly tied and taped in an airtight manner, and transported to the humid and dark mushroom production room.

Fifty holes were open each plastic bags with the help of needles to prevent excessive carbon dioxide accumulation. The logs were left to stand in these plastic bags for 35 days and moistened by injecting water into the bag with the help of a syringe (10 ml of each log) every ten days. After 35 days, the logs

were removed from the bags and placed in container (water basin) with an average height of 15 cm and a width of 30-40 cm and half of the containers were filled with water, water height kept stable with adding water to each container once in five days. During the micelle development stage (in plastic bags for 35 days) the room temperature was adjusted to 23-25°C and the humidity to 80-90%. During the fungal formation stage, the room temperature was adjusted to 13-17°C and the humidity to 80-90%.

Growing room has manual lighting and a window that can be closed in a light-proof way. In addition, the mushroom production room was lightened for 9 hours a day by using a fluorescent lamp (300 lm/m2) during the formation of the caps of mushrooms. The air exchange of the mushroom production room was provided every day and with the formation of primordiums, irrigation was done once in five days in the form of pulverization; thus the humidity rate was kept constant (80-90%).

Experimental design and statistical evaluation

The experiment was carried out in the mushroom research and production facility located in Canakkale Onsekiz Mart University Faculty of Agriculture according to the randomized plots trial design, with 3 replications with 3 substrates in each replication. SAS.9 package program was used for statistical analysis in the experiment, variance analysis was performed and LSD ($P<0.05$) test was used to compare the differences between the means of the data.

Analysis concerning yield and substrate

Yield Per Kg Substrate (6 Months): Each substrate was harvested for 6 months. Determined by calculating the yield value obtained from the total weight of each substrate by calculating a proportion of the yield value obtained from 1 kg substrate.

Biological Activity Rate (%): It will be calculated using the following formula (Kurt, 2008):

[Weight of Mushroom Harvested (g)/Dry Weight of Growing Substrate (g)]×100

Analysis and measurements related to mushroom quality

Physical and chemical analyzes were carried out by taking five samples from each replication in the applications. A scales with an accuracy of ±0.01 g was used for weight measurements in physical analyses. Measurements related to the length were made with the help of a caliper with an accuracy of ±0.1 mm.

Mushroom Weight (g): It was determined by averaging the weights mushrooms (stem + cap) collected from each replication; mushrooms were cut from the region where the stalk meets the nutrient substrate.

Cap Diameter (cm): It was determined by measuring the widest and narrowest diameter lengths of the cap.

Stalk Diameter (cm): It was determined by taking the average of three diameter measurements taken from the regions where the stalk meets the cap, the region where the stalk meets the substrate and the middle part of the stalk.

Stalk Length (cm): It was determined by measuring the stalk length of each of the five mushrooms.

Dry Matter (%): The harvested mushrooms were weighed and percentage dry matter determinations were made (Kurt, 2008). For the purpose of dry matter determination, the samples were first kept in a

drying cabinet set at 70°C until their weight remained constant and their dry weight was determined using a balance with a sensitivity of 0.01 g. The dry matter amounts of the samples were determined using the formula:

Dry Matter (%) = (Dry weight/Fresh weight)×100.

pH and Total Acidity: The pH of the homogenized samples was directly measured, the total acidity value was determined by adding 80 ml of distilled water to 20 g sample and titration with 0.1 N NaOH until pH 8.1 and the total acidity value was calculated in terms of anhydrous citric acid according to the formula below (Emir, 1998).

%Total Acidity = V×N×f×0.006404×100/m

V=Amount of NaOH consumed in titration (ml)

N=Normality of NaOH used in titration

F=NaOH factor

M=Sample quantity (g)

Protein Analysis (%): Nitrogen determination in dried and ground mushroom samples was made according to the modified Kjeldahl method (Kurt, 2008). The amount of protein was calculated by multiplying the found nitrogen value with a factor of 6.25 and expressed as % (percent) (Kurt, 2008).

Flavor Value: Mushroom samples were cooked in the oven and tasted by 5 different people, and they were asked to give a flavor value between 1 and 10.

Color Value (L-Luminance Value): It was measured from the top of the caps of the mushrooms with the help of a Konica Minolta colorimeter.

Results and Discussion

At the end of the 35 days incubation period of the linden logs (the stage in which they wait in the perforated bag), it was observed that the fungi did not spread in these logs (there were no white colour on the logs) and this subject was excluded from the study. Mushrooms either not develop fully or not develop at all on resinous trees. Although it is not certain, it is thought that the failure of fungi to grow in linden logs may be due to the distinctive odor of the linden logs or the cultivation method was not suitable for the mycelium for growing in linden log substrate.

In the present study, the highest yield was obtained in the beech substrate ($P<0.05$). Poplar substrate took the second place in terms of yield value ($P<0.05$) (Table 1). In a study (Doğan, 2019) which the economic analysis of oyster mushroom (*P. ostreatus*) production on logs was carried out in a greenhouse established with plastic cover material in the Kastamonu region; poplar logs with 20-50 cm diameter and 28-74 cm height were used. It was stated that in the first year of the study (in the period of March 2014-February 2015), 69.917 kg of product was obtained from 64 beech logs, and 8.535 kg of product was obtained from 30 poplar logs (Doğan, 2019).

Table 1. Effects of different substrates on yield per 1 kg substrate (6 months) in oyster mushroom (*P. ostreatus*).

Substrates	Yield Per 1 kg Substrate (6 months) (g) (45-50 Days After Incubation)
Poplar	135.7 A
Beech	141.6 B
Chestnut	94 B
LSD P<0.05	9.7137
Substrates	Yield Per 1 kg Substrate (6 months) (Other Harvests)
Poplar	42.29 B
Beech	58.22 A
Chestnut	36.91 B
LSD P<0.05	13.578
Substrates	Yield Per 1 kg Substrate (6 months) (Total Harvest)
Poplar	178.01 B
Beech	199.86 A
Chestnut	131.02 C
LSD P<0.05	17.5750

It was determined at the statistical significance level with P<0.05.

In another study (Pekşen, 2013), it was reported that with inoculating of mycelium to poplar tree logs (30-40 cm diameter and 40-50 cm length), yield can be obtained for 3-5 years as 2-5 kg/log. It has been observed that the yield amount of poplar and beech substrates (20-30 cm in diameter and 30-40 cm in height) for 6 months in our study is higher than the yield per log (20-50 cm tall with a diameter of 28-74 cm) in a year in the study (Doğan, 2019). This situation may have been caused by protection from living factors such as insects and mice which are present in natural conditions. In addition, in our study, the fact that the logs are in containers filled with water accelerates the decay of the logs, thus facilitating the uptake of nutrients in the substrate.

While the values of oyster and poplar substrate were similar in terms of cap weight and cap diameter values, the lowest values were obtained in the chestnut substrate (P<0.05) (Table 2).

Table 2. Effects of different substrates on cap weight (g) and cap diameter (mm) parameters in oyster mushroom (*P. ostreatus*).

Substrates	Cap Weight (g)	Cap Diameter (mm)
Poplar	37.12 A	70.75 A
Beech	38.13 A	73.72 A
Chestnut	28.44 B	62 B
LSD P<0.05	5.8866	7.732

It was determined at the statistical significance level with P<0.05.

Table 3. Effects of different substrates on stalk length (mm) and stalk diameter (mm) parameters in oyster mushroom (*P. ostreatus*).

Substrates	Stalk lenght (mm)	Stalk diameter (mm)
Poplar	11.24 A	11.24 A
Beech	10.85 A	10.85 A
Chestnut	8.72 B	8.72 B
LSD P<0.05	2.1049	2.182

It was determined at the statistical significance level with P<0.05.

Poplar and beech substrates were found to be statistically similar (P<0.05) in terms of stalk length and stalk diameter values. It has been determined that poplar and beech substrates have higher values than chestnut substrate in terms of the aforementioned values (Table 3).

Table 4. Effects of different substrates on dry matter (%) parameter in oyster mushroom ((*P. ostreatus*).

Substrates	Dry matter (%)
Poplar	7.92 B
Beech	8.86 A
Chestnut	7.7 B
LSD P<0.05	0.6005

It was determined at the statistical significance level with P<0.05.

The dry matter value of the mushrooms grown in the beech substrate was found to be higher than the other substrates (P<0.05). It was determined that other substrates had similar dry matter values (P<0.05) (Table 4). In a study (Kurt, 2008), the amount of dry matter in oyster mushroom (*Pleurotus ostreatus*) grown in different substrates varied between 6.95 (Sesame stalk)-8.02 (2:1 ratio of vine pruning residue/bran).

Table 5. Effects of different substrates on the biological activity rate (%) parameter in oyster mushroom (*P. ostreatus*).

Substrates	Biological activity rate (%)
Poplar	1.87 B
Beech	2.1 A
Chestnut	1.37 C
LSD P<0.05	0.1849

It was determined at the statistical significance level with P<0.05.

Beech and poplar substrates were similar and had higher biological activity rates than chestnut substrate (P<0.05) (Table 5). In a study (Sözbir, 2021) oyster mushroom (*P. ostreatus*) was grown in different substrates and the biological efficiency ratios of the substrates were varied between 1.43 (50% oak sawdust + 50% olive pulp substrate) and 14.05 (75% oak sawdust + 25% fiber waste substrate).

The reason for the low rate of biological activity in our study may be due to the log substrates have a usage period of up to 3 years. Additionally, since the material is not broken down, it may be more difficult to consume.

The pH values in the aforementioned study were similar to our study. It was observed that the TETA values in the aforementioned study were slightly lower than the TETA values in our study (Table 6).

Table 6. Effects of different substrates on pH log(h^+), teta (%), brix (%) parameters in oyster mushroom (*P. ostreatus*).

Substrates	pH log(H^+)	TETA (%)	Brix (%)
Poplar	5.98 B	0.03	5.8
Beech	6.49 A	0.04	5.7
Chestnut	6.25 AB	0.03	5.9
LSD P<0.05	0.3918	N.S.	N.S.

It was determined at the statistical significance level with P<0.05., N.S.: Not significant

Baydaş and Altundaş (2019), determined some biotechnical properties and drying characteristics of oyster mushroom (*P. ostreatus*) grown on straw (95%) + wheat bran (5%) and determined the L (Brightness) color value as 79.40 on the stalk in the fresh sample, 81.01 on the cap and Brix as 6.67 on the stalk and 7 on the cap. However, lower brix values obtained in our study (Table 6). In the study by (Emir, 1998), the effects of different washing solutions and packaging materials on the quality of mushrooms (*A. bisporus*) stored under MAP (modified atmosphere) conditions were investigated, before storage the pH values were determined between 6.8-7 and the TETA values were determined between 0.015-0.02. In the study, no significant difference (P<0.05) was observed between the flavor values of the substrates (Table 7).

Table 7. Effects of different substrates on flavor value parameter in oyster mushroom (*P. ostreatus*).

	Flavor Value (1-10)
Poplar	9
Beech	9.44
Chestnut	9.11
LSD P<0.05	N.S.

It was determined at the statistical significance level with P<0.05. N.S.: Not significant

It was determined that mushrooms grown in poplar and beech substrate had similar brightness values and brighter colors than chestnut substrates (P<0.05) (Table 8).

The highest protein value was obtained from mushrooms grown in chestnut substrate. This value was followed by mushrooms grown in poplar and beech substrates, respectively (P<0.05) (Table 9.).

Table 8. Effects of different substrates on color (luminance-l) value in oyster mushroom (*P. ostreatus*).

	Color (Luminance-L) Value
Poplar	65.61 A
Beech	66.1 A
Chestnut	64.76 B
LSD P<0.05	0.5646

It was determined at the statistical significance level with P<0.05.

In the study conducted by (Avcı, 2015), oyster mushroom (*P. ostreatus*) was grown in different substrates and its protein values (N×6.25) were between 31.02% (80 linden sawdust+20 wheat bran) and 11.91% (beech log). The protein content of poplar log and beech log substrates were determined as 13.77%, and 11.91% respectively (Avcı, 2015). When the study is examined (Avcı, 2015), it is seen that higher protein amounts determined in our study.

In the study (Hoa et al., 2015), *P. ostreatus* grown in 100% sawdust substrate obtained from acacia tree; and the protein amount determined as 19.52%. It is seen that the aforementioned protein value (Hoa et al., 2015) is between the protein values obtained from beech and poplar substrates in *P. ostreatus* in our study.

Table 9. Effects of different substrates on protein value (%) in oyster mushroom (*P. ostreatus*).

	Protein Value (%) (N×6,25)
Poplar	21.83 A
Beech	18.87 C
Chestnut	27.31 B
LSD P<0.05	1.075

It was determined at the statistical significance level with P<0.05.

Beech substrate had the highest yield. Shredded or soft-structured substrates can also be used as substrates in mushroom production. It should be noted that this situation may cause the substrate to consume by mushrooms more easily and causes mushrooms yield in a shorter time compared to log substrates. In addition, when the fruit characteristics related to the external appearance affecting the marketing were examined (cap weight, cap diameter, Luminance-L value), it was seen that the mushrooms obtained from beech and poplar substrates had similar and higher marketing values than the mushrooms obtained from chestnut substrate. However, it was observed that the chestnut substrate had the highest protein value in the study. Beech substrate had the most yield while had the lowest protein value.

There was no difference between the substrates in terms of Brix values. It was observed that the beech substrate had the highest dry matter ratio. Considering that the total yield and protein ratios are inversely proportional; in terms of the study results the beech substrate can be recommended for cultivation with the aim of high yield, while chestnut medium can be recommended for cultivation with the aim of high protein value.

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