RESEARCH ARTICLE

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# Effects of different agricultural wastes on yield and quality in *Pholiota nameko* cultivation

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## Abstract

*Pholiota nameko* is commonly consumed in the Far East but not yet known or grown in Türkiye. Therefore, in this study, determination of the cultivation conditions of *P. nameko* in different substrate mixtures and the effect of these substrates on yield and quality were investigated. In this research, six different substrate mixtures were used: 2 oak sawdust + 1 wheat bran (C), 2 peanut waste + 1 wheat bran (O1), 1 oak sawdust + 1 peanut waste + 1 wheat bran (O2), 2 almond shell + 1 wheat bran (O3), 1 oak sawdust + 1 almond shell + 1 wheat bran (O4), 2 wheat straw + 1 wheat bran (O5) and 1 oak sawdust + 1 wheat stalk + 1 wheat bran (O6). During the study, mycelia development time, biological efficiency rate (BE), total yield, mushroom weight, cap diameter, cap thickness, stipe diameter, stipe length, dry matter, pH and moisture content (in growing mixtures) were determined. pH and moisture content were recorded in three different periods; after sterilization, after mycelia development time and after harvest. As a result of the study, the fastest mycelial growth was obtained from the control group, with 14.25 days. The highest total yield and biological efficiency were obtained from O1 medium with 216.26 g $kg^{-1}$ and 49.11%, respectively. The highest amount of dry matter was recorded in O4 with 12.23%.

**Keywords:** *Pholiota nameko*, Mushroom, Agricultural wastes, Cultivation, Türkiye

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## INTRODUCTION

Mushrooms have been known and used for nutritional and medicinal purposes from the past to the present. In addition to their high water content (88-91%), they contain many amino acids, vitamins and minerals (Matilla et al., 2002). Mushroom protein is identified as high quality and digestible. Proteins consist of different amino acids and nine of the amino acids are known as essential amino acids (lysine, methionine, tryptophan, threonine, valine, leucine, isoleucine, histidine, phenylalanine) (Chang and Miles, 2004; Taşkın and Büyükalaca, 2019). In addition, extracts obtained from medicinal mushrooms have begun to be used in multivitamin pills. Today, as the value of the mushroom is better understood, the curiosity and interest in its cultivation have increased rapidly. Mushroom cultivation does not require land and does not depend on climate. Also, all family members including children can work in mushroom production. All these make mushroom cultivation advantageous compared to other agricultural activities (Taşkın ve Büyükalaca, 2019).

Mushroom production in the world has increased continuously over the years.

While cultivated mushroom production in Türkiye was 7 thousand tons in 2000, it has reached 61 thousand tons today (TÜİK, 2021). The most cultivated mushroom species in the world is *Agaricus bisporus*. This is followed by *Pleurotus* species with 27% production and *Lentinula edodes* with 17% production. These three species constitute 74% of the total cultivated mushroom production in the world (Eren and Pekşen, 2016). Other species, such as *Grifola frondosa*, *Ganoderma lucidum*, and *Pholiota*, are also produced in small quantities around the world. *P. nameko* (T. Itô) S. Ito & S. Imai (*P. microspora*) has a slippery and smooth mucus layer on its surface. This mucus is thought to be useful for energizing human brain's cognitive functions (Li et al., 2010). *P. nameko*, besides being delicious, contains crude protein, fat and carbohydrates, crude fibre, calcium, phosphorus, iron, multivitamins, and various amino acids (Meng et al. 2019). Cultivation of *P. nameko*, also known as *P. microspora*, was first performed in Japan (Zhu et al, 2016). In Japan, freshly cut wood logs were used to grow *P. nameko* in 1921. While most fungal species cannot effectively use freshly cut wood, *P. nameko* can use logs containing living cells. Sawdust spawn was first used in 1931, and in 1960, wheat bran, rice bran and sawdust were used in the commercial culture of P. *nameko* (Neidleman, 2004; Gizaw, 2015). It is one of the most produced and popular mushrooms speciesin Japan and China, and its production quantity is very close to *L. edodes* and *F. velutipes* (Gizaw, 2015).

The huge volume of different agricultural wastes produced after the harvesting and processing of agricultural products has emerged as an important environmental problem. These agricultural wastes are usually burned or thrown into the environment. A total of 600 million tons of waste (100 million tons of forest industry waste and 500 million tons of agricultural waste) are generated every year and regarded as environmental pollution. With such a high amount of waste, approximately 360 thousand tons of mushrooms can be produced. Cultured mushroom species are saprotrophic, and wood logs have been used in their cultivation as sawdust. However, new environmental protection policies and their implementations safeguard and limit the use of forest products. This situation pushes mushroom producers to find alternative substrate materials to wood (Meng et al. 2019).

In this study, it was aimed to culture P. nameko, which is not yet produced in Türkiye, in different agricultural wastes generated in Türkiye in order to determine the substrate mixtures that provide the best yield and quality, as well as to detect the ideal cultivation conditions of P. nameko, aiming to establish a new income source for local mushroom producers.

## MATERIALS AND METHODS

This study was carried out at Prof. Dr. Saadet BÜYÜKALACA tissue culture laboratory and in the mushroom growing rooms of Cukurova University (Adana, Türkiye) between 2020 and 2021. *P. nameko* spawn was obtained from a private company. In the experiments, oak sawdust, peanut waste, almond shell and wheat stalk were used as agricultural wastes. In addition, wheat bran and soy flour were added (Table 1).

**Table 1.** Growing mixtures content used in *Pholiota nameko* production

| Substrates | Short names |
|---|---|
| 2 oak sawdust + 1 wheat bran | C |
| 2 peanut waste + 1 wheat bran | O1 |
| 1 oak sawdust + 1 peanut waste + 1 wheat bran | O2 |
| 2 almond shell + 1 wheat bran | O3 |
| 1 oak sawdust + 1 almond shell + 1 wheat bran | O4 |
| 2 wheat stalk + 1 wheat bran | O5 |
| 1 oak sawdust + 1 wheat stalk + 1 wheat bran | O6 |

All of the substrates were crushed and were soaked in the tap water filled containers until obtaining suitable moisture (70%). After this step, pH adjustment of substrates was performed with a pH meter. If the pH was not appropriate, lime was added. Substrates were filled into 1 kg high temperature resistant polypropylene bags. The bags were sterilized in the autoclave for 90 minutes at 1.2 atm pressure at 121°C. Following the cooling of the bags, spawn inoculation was carried out in the sterile bench using 25- 30 g spawn per bag.

After the inoculation process, the bags were transferred to the mushroom growing rooms, which had 22±1°C temperature and 70-80% humidity. With the development of mycelia, the humidity was reduced to 18 ±1°C. With the observation of mushrooms' development, the ventilation of the room and the humidity level were kept between 90-95% to keep the moisture safeguard the moisture of substrates. Since *P. nameko* does not require light for the development of mycelia, room lighting was not performed at this stage. After observing the first fruit bodies, room lighting was carried out for 12 hours at 200 lux. With the completion of the mycelia development, the bags were cut into 5 cm small openings with the sterile scalpel to encourage the formation of mushrooms. During experiments, biological efficiency rate, total yield, mushroom weight, cap diameter and thickness, stipe diameter and length, as well as dry matter content were measured. In addition, pH and moisture analyzes of substrates were carried out at three different periods: after sterilization, after mycelia development and after harvest. Cap diameter-thickness, stipe diameter and length were measured (in mm) with a caliper in five samples.

Total yield and mushroom weight were determined (in g) on a scale. For dry matter amount, fresh samples were weighed and dried at adjusted temperatures of 65°C until their weight became constant. Then, the dried samples were weighed and the dry matter of all samples was detected (in %). The biological efficiency rate was calculated according to Royse (1985).

This study was carried out according to the randomized complete block design, with three repetitions and three bags in each repetition. The collected data were analyzed in the JMP statistical program. LSD test was performed on the data where the difference is statistically significant. In addition, JMP correlation analysis was applied to the treatments thought to have a relationship.

## RESULTS AND DISCUSSION

### Mycelia development time, biological efficiency rate, total yield and mushroom weight of *Pholiota nameko* grown in different growing mixtures

Mycelia development was observed in all growing mixtures in this study and differences in mycelia development times were found to be statistically significant (Table 2). Mycelia development times ranged between 14.25 and 29.00 days. The fastest mycelia development was observed in the control with 14.25 days and in O6 with 15.75 days. The slowest mycelia development was recorded in O2 with 28 days and in O1 with 29 days (Table 2). While oak sawdust in the growing mixtures positively affected mycelia development, peanut waste and almond shell caused a delay. Mycelia development time may vary depending on mushroom strains, spawn quality, environmental conditions of the mushroom growing rooms and substrate characteristics (Sánchez, 2004). In a study conducted by Rong et al. (2016), five different *P. nameko* isolates were cultured in a growing mixture including 60% cotton seed shell, 18% sawdust, 15% wheat bran, 5% corn flour, 1% gypsum and 1% lime. As a result of their study, while the highest mycelial growth rate was obtained from the JZB2116005 isolate with 2.56±0.03 mm/g, the lowest mycelial growth rate was recorded in the control JZB2116001 isolate with 2.34±0.01 mm/g. *Pholiota microspora* was cultured in five different growing mixtures including poplar sawdust, corn stalk, wheat bran, corn flour, soybean, gypsum and lime by Meng et al. (2019). The highest mycelial development was observed in T2 (38% poplar sawdust, 38% corn stalk, 15% wheat bran, 5% corn flour, 2% soy flour, 1% gypsum-lime) and T3 (19% poplar sawdust, 57% corn stalk, 15% wheat bran, 5% corn flour, 2% soy flour, 1% gypsum-lime) mixtures. In a study by Hal et al. (2021), the effects of different growing mixtures on the yield and quality of G. lucidum were tested. The spawn of *G. lucidum* was inoculated into eight different growing mixtures and the mycelia development time varied between 28.00 and 44.67 days. The shortest time was observed in mixtures of oak sawdust-peanut shell-wheat bran and vine pruning waste-wheat bran with 28.00 days. Kara et al. (2021) investigated the effects of six different growing mixtures on the yield and quality of *Grifola frondosa*. Mycelia development time varied between 35.00 and 41.67 days. The fastest mycelia development was determined in the mixture of oak sawdust and wheat straw, with 35.00 days.

As mycelia development time, the biological efficiency rate varies depending on the substrate mixtures, mushroom strains and environmental conditions (Barreto et al. 2008). In this study, the biological efficiency rate varied between 20.02 (O4) and 49.11 (O1) and it was found to be statistically significant (Table 2). The highest biological efficiency rate was observed in O1 and was followed by C and O4. Although the mycelia development completed in O2, O3, O5 and O6, fructification could not occur. Therefore, the biological efficiency rate could not be determined. Gizaw (2015) tested six different growing mixtures for the cultivation of *P. nameko*. The highest yield (797.33 g) and biological efficiency (53.27%) were obtained from the mixture of eucalyptus sawdust and wheat bran. This was followed by a mixture of 30% wheat bran and cotton seed (732.33 g). The lowest average yield (550.8 g) and biological activity rate (48.98%) were obtained from the mixture of 10% wheat bran and *Cordia africana* sawdust. Rong et al. (2016) inoculated five different *Pholiota* isolates into a substrate containing 60% cottonseed hull, 18% sawdust, 15% wheat bran, 5% corn flour, 1% gypsum and 1% lime. The highest biological efficiency was obtained from JZB2116005 with 67.88%, while the control JZB2116001 isolate had the lowest rate with 41.35%. When some studies performed with different mushroom species were examined in terms of biological efficiency, it was found to be between 5.31% and 16.37% in *G. lucidum* (Hal et al. 2021), between 93.65% in *L. edodes* (Baktemur et al., 2022), between 17.34% and 44.86% in *Pleurotus eryngii* (Baştuğ, 2021), between 22.83% and 29.29% in *G. frondosa* (Kara et al. 2021).

The total yield of *P. nameko* cultivated on different substrate mixtures was given in Table 2 (Figure 1). Yield values varied according to the substrate materials used. The highest yield value was obtained from O1 with 216.26 g $kg^{-1}$, followed by the control with 163.71 g $kg^{-1}$ and O4 with 88.96 g $kg^{-1}$. Fructification did not occur in O2, O3, O5 and O6 mixtures. The highest yield was obtained from the peanut waste and wheat bran mixture. It is observed that the use of peanut waste, which is an important agricultural product in the Çukurova region of Türkiye, has a positive effect on the yield of *P. nameko*. In the mixtures prepared using the wheat stalk, which is widely cultivated in the region, mycelia development has been fast, but mushroom formation has not been realized. Meng et al. (2019) determined differences between the yield

values of *P. microspora* in five growing mixtures, including poplar sawdust, corn stalk, wheat bran, corn flour, soy flour and gypsum at different ratios. When the total yield values were compared, the highest yield values were obtained from T2 (38% poplar sawdust, 38% corn stalk, 15% wheat bran, 5% corn flour, 2% soy flour, 1% gypsum-lime) with 275.66 g and T3 (19% poplar sawdust, 57% corn stalk, 15% wheat bran, 5% corn flour, 2% soy flour, 1% gypsum-lime) with 255.3 g. The yield was found to be between 25.00 and 68.44 g $kg^{-1}$ in nine different growing mixtures, including oak-poplar-beech sawdust, wheat, bran and paddy at different ratios in *G. lucidum* by Erkel (2009). In another study, the average yield of *P. ostreatus* and *P. florida* was reported to be between 27.0 and 42.0 g 100 $g^{-1}$ and 28.3 and 34.0 g 100 $g^{-1}$, respectively (Kırbağ and Korkmaz, 2013). In a study carried out by Baktemur et al. (2022), the average yield values varied between 55.99 and 299.59 g kg-1. Among the substrates, the highest yield was found in the mixture of oak sawdust, wheat stalk and wheat bran with 299.59 g $kg^{-1}$. Hal et al. (2021) found the highest and lowest yield values in corncob-bran mixture and control oak sawdust with 66.58 g $kg^{-1}$ and 25.32 g $kg^{-1}$ respectively, in *G. lucidum*. In a study performed by Kara et al. (2021), it was reported that the average yield of *G. frondosa* varied between 124.82 and 55.02 g $kg^{-1}$.

**Figure 1**. Pholiota nameko obtained from this study

In Table 2, the mushroom weight of *P. nameko* cultivated on different growing mixtures is presented. Differences between mixtures were found to be statistically significant. There was no statistical difference between the weight of mushrooms obtained from O1 (16.30 g) and O4 (16.66 g) and the highest weight was obtained from these two mixtures. It was followed by the control group with 11.93 g. Yen (2008) reported that the average mushroom weight of *G. lucidum* isolates in different sawdust mixtures was between 11.38 g and 15.16 g. Yakupoğlu and Pekşen (2011) stated that the average mushroom weight of *G. lucidum* varies between 7.99 g and 31.19 g. The average mushroom weight was 21.21 g in *P. ostreatus* and 16.73 g in *P. sajor-caju* (Kurt, 2008) and was between 10.14 and 39.47 g in *L. edodes* (Sözbir, 2014). In a study conducted by Ranjbar et al. (2017), the highest mushroom weight of L. edodes was detected in the mixture with rice bran as 33.51 g. Baktemur et al. (2022) reported that the mushroom weight in *L. edodes* varied between 33.52 and 14.98. Kara et al. (2021) determined the maximum and minimum mushroom weight in E5 and E4 mixtures as 33.92 g and 17.26 g respectively, in *G. frondosa*.

**Table 2.** Mycelia development time (days), biological efficiency rate (%), total yield (g $kg^{-1}$) and mushroom weight (g) of *Pholiota nameko* cultivated in different growing mixtures

| Growing mixtures | Mycelia development time | Biological efficiency rate | Total yield | Mushroom weight |
|---|---|---|---|---|
| C | 14.25 D | 38.31 B | 163.71 B | 11.93 B |
| O1 | 28.00 A | 49.11 A | 216.26 A | 16.30 A |
| O2 | 29.00 A | - | - | - |
| O3 | 24.50 B | - | - | - |
| O4 | 24.75 B | 20.02 C | 88.96 C | 16.66 A |
| O5 | 17.75 C | - | - | |
| O6 | 15.75 CD | - | - | |
| | LSD***= 2.62 | LSD***= 8.12 | LSD***= 35.47 | LSD***= 2.71 |

1. The statistical differences between the averages shown in separate letters in the same column were found to be significant.
2. N.S. Not Significant; *. P<0.05. **p ≤ 0.01. ***p ≤ 0.001

## Dry matter amount, cap diameter-thickness and stipe diameter-lenght of *Pholiota nameko* grown in different growing mixtures

The amount of dry matter of the *P. nameko* cultivated in different mixtures is given in Table 3. Differences between the mixtures in terms of the amount of dry matter were found to be statistically significant. The highest amount of dry matter was obtained from the O4 (12.23%), followed by C (10.31%) and O1 (10.67%) and there was no statistical difference between these two mixtures. In a study carried out by Baktemur et al. (2021), it was found that the average amount of dry matter varies between 8.59% and 11.65 % in *L. edodes*. The highest amount of

dry matter was obtained from the mixture of peanut shell and wheat bran with 11.65%. This was followed by the mixture of oak sawdust, corncob and wheat bran (11.21%) and the mixture of oak sawdust, vine pruning waste and wheat bran (10.99%). Kara et al. (2021) reported that the amount of dry matter of *G. frondosa* ranged from 13.57% to 14.79%.

The cap diameter-thickness, stipe diameter and length of the P. nameko samples which were cultivated in growing mixtures prepared by mixing different substrates at different ratios, were measured with a caliper and recorded in mm. It was determined that there was a statistically significant difference between these values (Table 3). It was observed that the cap diameter of the mushroom samples (68.04 mm) obtained from the O1 was larger. The cap diameter value of the mushrooms obtained from C (41.22 mm) and O4 (41.47 mm) was statistically in the same group. Yakupoğlu and Pekşen (2011) reported that the cap diameter of *G. lucidum* was between 42.8 mm and 84.5 mm. Atila (2020) stated that the cap diameter of *G. lucidum* was between 58.0 and 92.4 mm. The average cap diameter value of *L. edodes* ranged from 45.36 to 61.33 mm and the highest cap diameter value was obtained from the mixture of vine pruning waste and wheat bran as 61.33 mm (Baktemur et al. 2022).

There was no statistically significant difference between O1 (68.04 mm) and O4 (10.21 mm) for the cap thickness parameter, and the highest values were obtained from these mixtures. The cap thickness of the mushrooms obtained from the control group was lower. Veena and Pandey (2011) reported that the average cap thickness of *G. lucidum* varies between 6.9 and 8.1 mm. Hal et al. (2021) found that average cap thickness ranged from 8.68 to 10.24 in *G. lucidum* and the highest result was obtained from a mixture of corncob and wheat bran.

The highest stipe diameter was obtained from C (23.18 mm). This was followed by O1 (13.74 mm) and O4 (12.68 mm), respectively. It has been reported that the average stipe diameter value varies between 8.89 and 27.24 mm (Baktemur et al., 2022). For the stipe length, C (48.89) and O1 (51.67) were statistically in the same group. Average stipe length value changed between 21.31 and 49.11 mm in *L. edodes* cultured different growing mixtures (Baktemur et al., 2022). While the highest stipe length was obtained from a mixture of wheat stalk and wheat bran with 63.28 mm, the shortest value was recorded in the mixture of oak sawdust and wheat bran with 40.49 mm in *P. eryngii* by Baştuğ (2021).

**Table 3.** Dry matter amount (%), cap diameter-thickness (mm) and stipe diameter-lenght (mm) of Pholiota nameko cultivated in different growing mixtures

| Growing mixtures | Dry matter amount | Cap diameter | Cap thickness | Stipe diameter | Stipe lenght |
|---|---|---|---|---|---|
| K | 10.31 B | 41.22 B | 8.97 B | 23.18 A | 48.89 AB |
| O1 | 10.67 B | 68.04 A | 10.61 A | 13.74 B | 51.67 A |
| O4 | 12.23 A | 41.47 B | 10.21 A | 12.68 B | 37.07 B |
| | LSD*** = 0.52 | LSD*** = 11.94 | LSD*** = 1.06 | LSD*** = 4.26 | LSD*** = 14.37 |

## pH values of *Pholiota nameko* grown in different growing mixtures

The pH values of the growing mixtures used in *P. nameko* cultivation at three different periods are given in Table 4. The differences between the period average and the mixture x period interaction were found to be statistically significant, however, the mixture average was not statistically significant. Since the mushroom formation was not be provided from O3, O5 and O6 mixtures and infection problems in A4 after harvest, pH analysis could not performed in these mixtures.

The relationship between the mixture x period interaction was found to be important and the highest pH value was recorded in O1 and O2 as 8.33 and 8.44, and 8.44, respectively, at the after harvest period. The lowest pH value was determined in the control group at the after harvest period as 5.97. The average pH value of the mixtures has been statistically in the same group. In the analyses performed at different periods (after sterilization, after mycelia development and after harvest), there were statistical differences between the periods. There were no significant differences between the periods after sterilization and after mycelia development. Yakupoğlu and Pekşen (2011) reported that the pH values of the mixtures prepared using wood chips in *G. lucidum* were reported between 5.80 and 7.35, and they ranged from 5.70 to 7.05 in the mixture prepared using wood-chip. Atila (2020) found that the pH value of *G. lucidum* was between 4.43 and 6.42. Zadrazil (1978) stated that when pH value was higher than 8 and less than 4, the development of *Pleurotus* species is prevented and development of mycelia is slow in acidic mixtures (pH = 4) is slow. Sun and Yu (1989) determined that the mycelia of *P. sapidus* developed well in mixtures having pH 5.4-6.0 (Küçükomuzlu and Pekşen, 2005). Özçelik and Pekşen (2006) reported that pH of *L. edodes* ranged between 6.65 and 7.08. Adenipekun and Oklelade (2012) determined that the change in pH value may be associated with the presence of metabolic waste products in the mixture and the increase in amino nitrogen content. Kara et al. (2021) reported the most appropriate pH range for the cultivation of *G. frondosa* was between 5.20 and 5.45.

**Table 4.** pH values of Pholiota nameko grown in different growing mixtures at different periods

| Growing mixtures | Periods | | | |
|---|---|---|---|---|
| | After sterilization | After mycelia development | After harvest | Mean |
| C | 6.12 hı | 5.97 ı | 6.57 f | 6.22 |
| O1 | 7.50 b | 7.15 c | 8.33 a | 7.66 |
| O2 | 6.98 cd | 7.22 c | 8.44 a | 7.55 |
| O3 | 6.62 ef | 7.72 b | - | 4.78 |
| O4 | 6.29 gh | 7.64 b | - | 4.64 |
| O5 | 6.44 fg | 7.14 cd | - | 4.53 |
| O6 | 6.87 de | 7.08 cd | - | 4.65 |
| Mean | 6.67 A | 7.13 A | 3.33 B | |

LSDperiod*=0.11, LSDmixture=Ö.D., LSDperiodxmixture***=0.02

**Table 5.** Moisture content of *Pholiota nameko* grown in different growing mixtures at different periods (%)

| Growing mixtures | Periods | | | |
|---|---|---|---|---|
| | After sterilization | After mycelia development | After harvest | Mean |
| C | 64.50 de | 64.84 de | 59.99 fg | 63.11 |
| O1 | 68.21 bcd | 72.46 a | 62.94 ef | 67.87 |
| O2 | 63.43 ef | 65.76 cde | 70.46 ab | 66.55 |
| O3 | 48.28 h | 47.20 h | - | 31.83 |
| O4 | 57.17 g | 57.92 g | - | 38.36 |
| O5 | 70.80 ab | 70.25 ab | - | 47.02 |
| O6 | 70.9 ab | 69.36 abc | - | 46.77 |
| Mean | 63.33 A | 63.97 A | 27.63 B | |

LSDperiod**= 1.62, LSDmixtures= Ö.D., LSDperiodxmixture***= 4.28

### Moisture content of *Pholiota nameko* grown in different growing mixtures at different periods

Variance analysis was performed at three different periods in terms of the moisture content of the mixtures. Statistically significant differences have been determined in the mixture, period and their interaction. The highest moisture was recorded in O1 at after mycelia development period with 72.46 %. The lowest moisture content was obtained from O3 at after sterilization period (48.28%) and at after mycelia development period (47.20%). There was no statistically significant difference between after the sterilization period (63.33 %) and after mycelia development time (63.97%).

In a study conducted on *L. edodes*, the amount of moisture of the growing mixtures during the cultivation was examined. During the development, it was determined that the amount of moisture in the mixtures was maintained. The moisture amount was detected between 92.00 % and 93.85 % at the beginning of the study. It ranged from 90.90% to 95.44% at the fructification period (Morais et al. 2000). In *P. eryngii*, the highest and lowest moisture levels were determined at after sterilization period with 67.27% and after harvest period with 65.03%, respectively (Baştuğ et al. 2021). The highest moisture was recorded in the mixture of poplar sawdust and wheat bran with 72.10% and it was followed by wheat stalk and wheat bran mixture (71.12%) and oak sawdust, wheat stalk and wheat bran mixture (69.22%) (Baktemur et al. 2022). In *G. frondosa*, mixture x time interaction was found to be important and the highest amount of moisture was determined in E4 with 82.22% at after harvest period. The lowest value detected in E5 (67.12%) after sterilization period.

## CONCLUSION

During the study, many parameters were investigated to reveal the effects of the different substrate mixtures on the yield and quality of *P. nameko* mushroom. Although mycelia development was completed in all mixtures used, fructufication was observed in C, O1 and O4 mixtures. Since peanut is one of the main products of the Cukurova Region of Türkiye, it is very important that peanut waste can be used in mushroom cultivation in the region. It is recommended to try new substrates with peanut waste at different ratios. The wastes of wheat, which is intensively cultivated in the region, played an important role in shortening the period of mycelial development. It is also recommended to try new mixtures experiments based on wheat straw with different materials.

## COMPLIANCE WITH ETHICAL STANDARDS

### Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

### Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

### Ethical approval

Ethics committee approval is not required.

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### Data availability

Not applicable.

### Consent for publication

Not applicable.

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