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Polyporus squamosus (Huds.) Fr. in the Black Sea Region

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A R T I C L E I N F O

Review Articles

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A B S T R A C T

Polyporus squamosus (Huds.) Fr., also named as Aladana, Peri Semeri, Pullu Mantar in varying by localities of Turkey, is an edible wild mushroom species widely existed in the mycobiota of the Black Sea Region. It has not been sold in the local markets. The public recognition of this mushroom may change locally in the Black Sea Region. It is widely consumed by the people in some parts of the region. It is usually appeared in the nature during May-September on the logs, dead and living trunks of the deciduous trees. Following the rainy period, it grows so fast and can produce a few kilograms fruit body within a short period. It is delicious and precious as much as meat for the nutritional value, especially during early growth stage. In this review, general knowledge on the morphological and ecological characteristics, nutritional value and medicinal properties of *P. squamosus* mushroom and some study results on the domestication of this mushroom have been presented in order to improve the public awareness and its consumption.

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Karadeniz Bölgesi'nde *Polyporus squamosus* (Huds.) Fr.

M A K A L E B İ L G İ S İ

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Ö Z E T

"Aladana, Peri Semeri, Pullu Mantar" gibi farklı yerel isimlerle bilinen *Polyporus squamosus* (Huds.) Fr. Karadeniz Bölgesi mikobiyotasında yaygın olarak bulunan yenen bir yabani mantar türüdür. Mahalli pazarlarda satışı yapılmamaktadır. Bu mantarın tanınırlığı, Karadeniz Bölgesi'nde yöreden yöreye değişebilmektedir. Bölgenin bazı kısımlarında insanlar tarafından yaygın olarak tüketilmektedir. Genellikle doğada Mayıs-Eylül ayları boyunca yaprak döken ağaç türlerinin kütükleri, ölü ve yaşayan gövdeleri üzerinde görülmektedir. Yağışlı dönemin ardından, çok hızlı büyümekte ve kısa bir süre içerisinde birkaç kilogram gövde üretebilmektedir. Özellikle erken büyüme evresinde lezzetli ve besleyici değer bakımından et kadar değerlidir. Bu derlemede, halkın farkındalığını ve mantarın tüketimini artırmak amacıyla *P. squamosus* mantarının morfolojik ve ekolojik özellikleri, besin değeri ve tıbbi özellikleri ile bu mantarın kültüre alınması üzerine yapılmış bazı çalışma sonuçlarına ilişkin genel bilgiler sunulmuştur.

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Introduction

In recent years, there has been an evident increase in the consumption of both wild and cultivated mushrooms in Turkey. Mushrooms have very delicious taste and good flavor and also provide nutritive constituents such as dietary fiber, protein, mineral compounds and vitamins of group B that are important for human nutrition (Bernas et al., 2006). Besides their nutritional potentials, they produce a wide range of secondary metabolites that promote human health due to high therapeutic value (Oyetayo et al., 2009).

The Black Sea Region has a great diversity of macrofungi due to its climate and flora. The summers are relatively warm in the coastal area and the winters are moderate in the coastal area and snowy and cold in the highlands. All seasons are rainy and there is no water shortage. Natural vegetation consists of broad-leaved forests in the coastal zone and coniferous forests grown under cold and humid conditions in the highlands. The annual average temperature, rainfall and relative humidity are 13.0°C, 842.6 mm and 71%, respectively (Sensoy et al., 2000).

Polyporus squamosus (Huds.) Fr. is one of the edible wild wood-growing mushrooms of the Black Sea Region. It is an edible saprobe or parasite mushroom belonging to the Polyporaceae family. It is called as dryad's saddle mushroom or pheasant's back mushroom and characterized by innumerous pores under the cap. It has a widespread distribution in North America, Australia, Asia and Europe (Schmidt, 2006). The fruiting bodies of *P. squamosus* occur on living and dead hardwood trees during spring and autumn. Young fruiting bodies are soft, but toughen with age. Therefore, young fruiting bodies having good flavor and taste are more preferable for eating than the old ones (Pekşen and Kibar, 2016).

P. squamosus mushroom was previously identified by the researchers in different parts of the Black Sea Region (Abatay, 1983, 1984, 1985, 1988a, 1988b; Afyon and Konuk, 2002; Afyon et al., 2005; Akata et al., 2014; Anşin et al., 2000; Demirel and Uzun, 2006; Demirel et al., 2004; Işıloğlu et al., 1998; Pekşen and Karaca, 2000a, 2000b, 2003; Selik, 1973; Sesli, 1993, 1994, 2007; Sesli and Türkekul, 2000; Sesli and Tüzen, 1999; Solak et al., 1997; Türkekul, 2001, 2003; Türkekul and Zülfükaroğlu, 2010; Uzun et al., 2004, 2006; Yağız et al., 2006). Except the Black Sea Region, this species is also wide spread in the other regions of Turkey (Sesli and Denchev, 2014; Solak et al., 2015).

P. squamosus is well known and consumed by the people of the Black Sea Region (Özçelik et al., 2004; Pekşen and Kaplan, 2017). However, it is not known as an edible wild mushroom in some areas, so it is not collected from the nature and not sold in the local markets of these areas.

In this review, it was aimed to give basic information on the identification, morphological and ecological characteristics, nutritional value and medicinal properties of *P. squamosus* mushroom. In addition, the other aim of this paper is to present some study results on domestication of that mushroom in order to increase awareness of the public and become into more popular its consumption.

Morphological and Ecological Characteristics

Cap is half circle or fan in shape, 8-60 cm in diameter, 12-24 cm in width and covered with brown scales, irregularly arranged in straw yellow color. Stipe is 4-10×2-5 cm, lateral or occasionally off center, short; the close part of stipe to the cap is yellowish, the bottom part is blackish dark brown (Figure 1). The white fleshy portion is initially soft, then as hard as a strap. Its taste and smell are nice. The tubes are 5-10 mm long, irregularly distributed, angular, white or yellowish cream in color and extend towards the stipe. Spore print is white and spores are cylindrical or long elliptical, 10-15×4-5 µ in dimensions (Özçelik et al., 2004).

It is usually possible to find *P. squamosus* in the period of May-September, when they appeared in the nature. Logs, dead and living trunks of the deciduous trees are the most proper media for their growth (Özçelik et al., 2004). It is especially formed on the beech, willow, walnut, poplar, linden, ash, elm, plane, horse chestnut and fruit trees individually or in layers on top of each other. It grows very quickly after the rain and can reach a few kilograms in weight. The colors on the upper and lower surface darken while aging. This mushroom is also a scar parasite and causes white rot in the heartwood (Sümer, 1987).

Figure 1 *Polyporus squamosus*

Nutritional Value

It was reported that *P. squamosus* had a good nutritional value. Crude protein, crude fiber, fat and carbohydrate contents on a dry matter basis were determined as 35.70, 10.33, 3.85 and 43.76%, respectively (Ertan and Gülyavuz, 1991). The protein content was found as 2.75% and vitamin C as 48 mg/100 g by Şeker (1992). Uzun et al. (2009) found high protein content (64.70%) in a sample of *P. squamosus* from Turkey. In another *P. squamosus* sample from Turkey, Akata et al. (2012) found 7.14% ash, 13.32% protein, 3.98% fat and 65.24% carbohydrate on dry matter basis. According to Fernandes et al. (2016), *P. squamosus* sample from Portugal and Serbia contained 2.69 and 2.86 g/100 g fat, 3.15 and 8.42 g/100 g ash, 77.02 and 78.36 g/100 g carbohydrate and 17.14 and 10.65 g/100 g protein, respectively. Mocan et al. (2017) also reported that *P. squamosus* collected from Romania was rich in carbohydrates (74.22 g/100 g dw) and proteins (18.7 g/100 g dw).

Among organic acids, oxalic, malic and fumaric acids were quantified as 0.08, 1.33 and 0.1 g/100 g dw in *P. squamosus* samples from Portugal and as 0.45, 3.96 and 0.41 g/100 g dw in the samples from Serbia, respectively (Fernandes et al., 2016). Malic acid content was determined in the highest amount (2.21 g/100 g dw), while fumaric and oxalic acids were in much lower amounts (0.0003 g/100 g dw and 0.076 g/100 g dw) (Mocan et al., 2017).

It was detected that *P. squamosus* contained 17.21% palmitic acid, 33.02% cis-oleic acid and 38.91% cis-linoleic acid. SFA (saturated fatty acids), MUFA (monounsaturated fatty acids) and PUFA (polyunsaturated fatty acids) of total fatty acids contents were reported as 25.19, 34.27 and 40.64% on a dry basis, respectively (Ergönül et al., 2013). PUFA was about 57% and MUFA was 24.96% of the total fatty acids (Mocan et al., 2017). In another study conducted in Turkey, linoleic acid and stearic acid were determined as 74.60 and 1.06% in *P. squamosus*. In addition, total SFA, MUFA, PUFA, unsaturated fatty acid (UFA), essential fatty acid (EFA), omega-3 and omega-6 fatty acids and oil contents were detected as 15.89, 9.24, 74.88, 84.11, 74.84, 0.24, 74.64 and 1.26%, respectively (Zengin et al., 2015).

Dursun et al. (2006) studied the mineral matter contents of *P. squamosus* and the concentrations of Ca, K, Mg, Na, P and Fe were found as 189.7, 9973.8, 961.1, 385.2, 2095.6 and 254.5 mg/kg, respectively.

Medicinal Properties

Polyporus species are medicinal mushrooms possessing anti-inflammatory, antimicrobial, antioxidative, cytotoxic, diuretic, hepatoprotective, immuno-enhancing and nephroprotective activities (Ohsawa et al., 1992; Uan et al., 2004; Zhao et al., 2009, 2010; Zhao, 2013). Particularly, *P. squamosus* was shown to have antioxidant (Elmastas et al., 2007; Akata et al., 2012; Dimitrijevic et al., 2015; Mocan et al., 2017), immunomodulating (Babakhin et al., 1996), antibacterial (Dimitrijevic et al., 2015; Mocan et al., 2017), antiradical (Dimitrijevic et al., 2015), antifungal (Fernandes et al., 2016; Mocan et al., 2017) properties and also antibiofilm and anti-quorum sensing activities (Fernandes et al., 2016; Mocan et al., 2017).

Mushrooms are natural antioxidants. Highest antioxidant activities were measured in *P. squamosus* extracts from different origins (Elmastas et al., 2007; Akata et al., 2012; Fernandes et al., 2016). Elmastas et al. (2007) determined the scavenging effect of methanolic extract from *P. squamosus* species and standards on the DPPH radical was 82.8% at the concentration of 180 µg/mL. In the same study, the percentage inhibition of methanolic extract of dried *P. squamosus* at 100 µg/mL concentration on peroxidation in linoleic acid system was 98.4% and higher than those of the 400 µg/mL concentrations of α-tocopherol, BHA and BHT (77, 85 and 97%, respectively). The reducing power of *P. squamosus* methanolic extract increased with increasing concentration. The percentage inhibition of superoxide generation by 50 µg/mL concentration of methanolic extract of *P. squamosus* was found as 78%. The percentage of metal chelating capacity of 100 µg/mL concentration of methanolic extract of *P. squamosus* was found as 74.2%. The contents of β-carotene, α-tocopherol and total polyphenols of methyl alcohol extracts from *P. squamosus* were found as 0.02, 0.3 and 13.9 mg/g, respectively. Keleş et al. (2011) determined ascorbic acid <20 mg/kg, total phenolics 4531.11 mg/kg, FRAP 2242.86 µmol/g and DPPH 43.30% at the concentration of 25 µg/ml for *P. squamosus*, but the EC50 value was not determined in this study. It was reported that *P. squamosus* had 3.46 mg/mL extract concentration, 17.3% extraction yield and 95.35% radical scavenging activity (Akata et al., 2012). Shomali et al. (2016) reported that ethanolic extract of *P. squamosus* has been shown the highest total of phenolics (25.65 mg GAE/g) and flavonoid (12.36 QE/g values) contents. The highest DPPH radical scavenging was observed for ethanolic extract of *P. squamosus* with 0.329 mg/mL IC50 value. However, ethanol extract of *P. squamosus* had shown to have moderate effects on the bacteria strains inhibition. Fernandes et al. (2016) determined that the Portugal *P. squamosus* sample gave the highest antioxidant activity; highest reducing power, DPPH radical scavenging activity, and lipid peroxidation inhibition in both β-carotene/linoleate and TBARS assay. These results could be related to its higher content in total tocopherols (1968.65 µg/100 g) and phenolic compounds (1.29 mg/100 g). The total concentration of phenolic compounds in methanolic extracts of *P. squamosus* was 13.9 mg/g (Elmastas et al., 2007).

In a study conducted to evaluate and compare antioxidant, antimicrobial and antiradical activities of twelve wild edible mushrooms from Serbia, antioxidant activity was evaluated by DPPH and ABTS, total reducing power (TRP), ferric reducing antioxidant power (FRAP), cupric reducing antioxidant capacity (CUPRAC) methods. The highest EAU_{515} units were calculated for extracts obtained from the *P. squamosus* (EAU_{515} 6.35) and this extract could be considered as effective antiradical agent. Yield of ethanol extract was 2.11% for *P. squamosus*. The RSC-DPPH value for *P. squamosus* was 45.33%. Inhibitory activity of *P. squamosus* samples against *Staphylococcus aureus* were significant.

Moreover, CUPRAC (µg TE/1 mg dw), TRP (mg AAE/1 mg dw), FRAP (µmol Fe/1 mg dw) and TPC (µg GAE/1 mg dw) were reported as 15.48, 0.25, 23.34 and 49.75, respectively for *P. squamosus* (Dimitrijevic et al., 2015).

Domestication Studies

P. squamosus was examined for the ability of simultaneous production of pectinases and biomass in terms of animal nutrition, as well as for extractive cultivation in aqueous two-phase media containing pectin and sugar beet extraction waste (Antov and Pericin, 2001; Antov et al., 2001). Antov and Pericin (2001) reported that *P. squamosus* had the ability to grow and produce pectinases in an aqueous two-phase medium composed of polyethylene glycol and crude dextran and reported that the amounts of biomass produced by *P. squamosus* and endo- and exo-pectinase activities were superior or equal to those obtained in homogeneous medium. The partition coefficient for the endo-pectinase was 1.52 followed by a top phase yield of 70.86%. The cultivation of *P. squamosus* for pectinase production was studied in a polyethylene glycol/crude dextran aqueous two-phase system, with sugar beet extraction waste as pectin source (Antov et al., 2001). The partition coefficients of endo-pectinase and exo-pectinase were found as 4.26 and 2.78, respectively. The top phase yields in the single extraction step were about 90% for both pectinases.

Antov et al. (2006) found the appropriate conditions for efficient separation and partial purification of xylanase from crude enzyme obtained by solid-state cultivation of *P. squamosus* in aqueous two-phase system of polyethylene glycol/ammonium sulphate. The top phase yield in 10% (w/w) polyethylene glycol, 1500/20% (w/w) ammonium sulphate aqueous two-phase system at pH 5.1 were determined as 85.6 and 97.37%, respectively, followed by purification factor of 4.8.

Pekşen and Kibar (2009) carried out a study to determine the most suitable mycelial nutrient media, to optimize mycelium growth conditions as pH, temperature, C and N sources, and also to determine production methods which can be used in the cultivation of *P. squamosus.* The most suitable carbon source for mycelial biomass production in submerged culture of *P. squamosus* was the medium with xylose. In addition, yeast extract was determined to be the most favorable nitrogen source for *P. squamosus* (Pekşen and Kibar, 2016).

Conclusion

P. squamosus is an edible wild wood-decaying mushroom in the Black Sea Region and is important for its nutritional value and the content of bioactive compounds. Further studies on the nutritional value and medicinal properties of the samples belonging to different areas are needed to be carried out. Moreover, new studies on domestication and increasing of public consumption of this mushroom should be conducted. By the cultivation of this species, additional job opportunities and important contributions to country economy can be provided.

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