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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Impacts of Different Processing Techniques on Chemical and Mineral Components of Wild-Grown Edible Mushroom (*Lactarius semisanguifluus* R. Heim & Leclair)

Farklı İşleme Tekniklerinin Yabani Olarak Yetişen Yenilebilir Mantarın (*Lactarius semisanguifluus* R. Heim & Leclair) Kimyasal ve Mineral Bileşenleri Üzerine Etkileri

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Abstract

Lactarius semisanguifluus R. Heim & Leclair *(L. semisanguifluus)* is one of the wild-grown edible mushroom types. Wild-grown edible mushrooms are widely consumed or sold by people in fresh form. However, due to the high respiration ratio and moisture content, the mushrooms lose their quality immediately after harvest. This causes their shelf life to be very short. For this reason, it is necessary to know the best storage conditions as well as its nutritional content. The objective of this study was to investigate the effects of different treatment techniques (drying, canning, and freezing) on the chemical components (dry matter, crude protein, crude fats, ash, and total carbohydrates) and the mineral matters (Na, K, Mg, Ca, P, Fe, Mn, Cu, and Zn) of the *L. semisanguifluus*. The results show that the moisture content varied between 8.86% to 90.43% (w/w) in the fresh, dried, canned and frozen mushroom samples. The protein content of the with and without processed samples was in the ranged of 1.21% and 18.53%. The ash and fat content of the all samples ranged from 2.79% to 5.94% and from 0.53% to 7.99%, respectively. Additionally, the carbohydrate content was found to be between 0.85 and 58.68%. The energy values of the all samples were estimated to be between 27.56-380.75 kcal $100g^{-1}$ and 115.63-1608.20 kJ $100g^{-1}$. Potassium (108.6-2367.4 mg $100g^{-1}$) and phosphor (37.4-182.7 mg $100g^{-1}$) were the most abundant minerals in the analysed samples. The chemical composition of the frozen samples had the closest results to the fresh samples. The results of the present research showed that *L. semisanguifluus* has a high nutritional quality especially the freezing process is the best protection technique rather than the canning process and was suitable especially for consumption in low caloric diets. Based on overall evaluations, it can be deduced that especially dried mushroom samples can be used in powder form (such as spices and enrichment component in many food formulations) in the production of various food products due to their high nutritional components.

Keywords: *Lactarius semisanguifluus*, Wild mushroom, Nutritional content, Processing, Drying, Canning, Freezing

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Öz

Lactarius semisanguifluus R. Heim & Leclair *(L. semisanguifluus)* yabani olarak yetişen yenilebillir bir mantar türüdür. Yenilebilir yabani mantar çeşitleri insanlar tarafından genellikle taze olarak tüketilir ya da satılır. Ancak, yüksek solunum oranı ve nem miktarı nedeni ile mantarlar hasattan hemen sonra kalitesini kaybeder. Bu da raf ömürlerinin çok kısa olmasına neden olmaktadır. Bu nedenle, mantar çeşitlerinin besinsel içeriğinin yanısıra en iyi saklama koşullarının da belirlenmesi gerekmektedir. Bu çalışmanın amacı, yabani olarak yetişen ve insanlar tarafından sevilerek tüketilen, yenilebilir bir mantar çeşidi olan *L. semisanguifluus*'a uygulanan farklı işleme tekniklerinin (kurutma, konserve ve dondurma) kimyasal bileşim (kurumadde, ham protein, ham yağ, kül ve toplam karbonhidrat) ve mineral madde (Na, K, Mg, Ca, P, Fe, Mn, Cu ve Zn) miktarı üzerindeki etkilerini belirlemektir. Elde edilen sonuçlara göre; taze, kurutulmuş, konserve edilmiş ve dondurulmuş mantar numunelerinde nem içeriğinin %8.86 ile %90.43 arasında değiştiği tespit edilmiştir. İşlenmiş ve işlenmemiş örneklerin protein içeriği %1.21-18.53 arasında belirlenirken, kül ve yağ içerikleri ise sırası ile %2.79-5.94 ve %0.53-7.99 olarak belirlenmiştir. Ayrıca, örneklerin karbonhidrat içeriklerinin %0.85-58.68 olduğu ve enerji değerlerinin kcal cinsinden 27.56-380.75 kcal $100g^{-1}$ arasında kJ cinsinden ise 115.63-1608.20 kJ $100g^{-1}$olduğu tespit edilmiştir. Analiz edilen mantar örneklerinde potasyum (108.6-2367.4 mg $100g^{-1}$) ve fosfor (37.4-182.7 md $100g^{-1}$) en bol bulunan mineraller olarak gözlenmiştir. Çalışmada dondurulmuş mantar örnekleri kimyasal bileşim açısından taze örneklere en yakın sonuçları vermiştir. Mevcut araştırma sonuçları, *L. semisanguifluus*'un yüksek besinsel kaliteye sahip olduğunu ve özellikle düşük kalorili diyetlerde tüketimine uygun olduğunu göstermiştir. Çalışma sonucunda elde edilen tüm veriler değerlendirildiğinde ise özellikle kurutulmuş mantar örneklerinin sahip oldukları yüksek besinsel içerik nedeniye çeşitli gıda ürünlerinin üretiminde toz şeklinde (birçok gıda formülasyonunda baharat ve zenginleştirme bileşeni gibi) kullanılabileceği sonucuna varılabilir.

Anahtar Kelimeler: *Lactarius semisanguifluus*, Yabani mantar, Besinsel bileşen, İşleme, Kurutma, Konserveleme, Dondurma

1. Introduction

According to the previous obtained knowledge, mushrooms are widely distributed throughout the world (Aryantha et al., 2010). They contain edible, medicinal and poisonous species (Omer and Alfaig, 2020). 70,000 fungi are described by researchers all around the world, and approximately 10,000 of them are fleshy mushrooms. Among them, 2,000 species are recognized as edible and only 33 of them are cultivated (Mukerji and Manoharachary, 2010). Edible mushrooms are considered to be delicious due to their nutritional, medicinal and organoleptic properties (González et al., 2020; Doğan and Doğan, 2021). Mushrooms are recognized as important sources of fiber, micronutrients and functional compounds (Wasser, 2002; Xu et al., 2011; Valverde et al., 2015). Addition to this, flavour compounds such as alcohols, ketones, aldehydes and cyclic compounds, are major flavour components of mushrooms (Costa et al., 2013; Politowicz et al., 2018). They have, for that reason, been used as a food and food-flavouring agent for centuries (Kalyoncu et al., 2010). The significance of edible mushrooms is increasing day by day due to their nutritional and pharmacological properties (Diez and Alvarez, 2001).

Edible mushrooms, which have significant amounts of protein (Bach et al., 2017), draw attention with its low caloric content, large quantity of dietary fibre, and low-fat ratio (González et al., 2020). Considering edible mushrooms containing unsaturated fatty acids, phenolic compounds, tocopherols, ascorbic acid, and carotenoids, they can be accepted as a food source which can be used to prevent and treat diseases (Pereira et al., 2012). In previous studies, their positive effects on health, including their antimicrobial, antioxidant, antidiabetic (Doğan et al., 2021), anticancer, antiobesity, antibiotic (Freidman, 2016), antihypertensive, anti-inflammatory, antiviral, hypoglycaemic, hypolipidemic and immunomodulatory activities, were analysed (Rathore et al., 2017). Therefore, some of them are used as drugs in ethno-medicine.

Because of their sensorial properties and nutritional value, the consumption of wild edible mushrooms is increasing nowadays. Wild growing edible mushrooms have been a popular food source in most of European countries (Kalac, 2009). Turkey has a great potential for wild-grown edible mushrooms which are collected by the local community not only for home consumption in order to meet the requirement of protein but also for breadwinning. Mushrooms have been known as a valuable foodstuff since ancient times. The moisture content of fresh mushrooms is approximately 88-91%. With their easy digestible proteins, they have distinctive characteristics compared to vegetables (Erkel, 2000). Many scientists, who have studied wild edible mushrooms, reported that they contained high protein and low energy content (Barros et al., 2007a). Besides, mushrooms contain low carbohydrate and fat (Erkel, 2000).

Mushrooms contain varied minerals which can be used by the body to carry out various biological functions throughout the human body (Zeng et al., 2012). The mineral components of mushrooms vary hinge on species and ecosystems (Genccelep et al., 2009). Due to this reason, the mineral elements in mushrooms is unlike from plants in many respects. As a result of the rise of post-harvest changes, edible mushrooms have a short shelf life as approximately 1-3 days at room temperature (Barros et al., 2007b). As well as aroma and texture properties, visual appealing, such as the surface colour and appearance properties, indicates the freshness of mushrooms (Burton and Noble, 1993).

Considering all these results, a variety of conservation methods are used to ensure that people, who consume mushroom as a source of protein, are able to access it for a longer time. Manzi et al. (2004) reported that without seasonal limitations, drying and freezing treatments could be used to increase storage stability and to ensure mushroom consumption. Partially high protein content and lack of physical preservation to prevent water loss or microbial attack are related to high respiration ratio and moisture substance of mushrooms; the shelf life of mushrooms is, therefore, shortened due to post-harvest changes such as browning, cap opening, stipe elongation, increased cap diameter, weight loss, and texture damage (Fernandes et al., 2012). For this reason, mushrooms are generally used in processed form (Jaworska and Bernas, 2009) such as dried, frozen or canned form. The mushrooms are also can be used in the production of biscuits (Farzana and Mohajan, 2015), instant noodle (Arora et al., 2018), chips (Doğan et al., 2020), beef patties (Cerón-Guevara et al., 2019), and snack (Rachappa et al., 2020).

Lactarius semisanguifluus R. Heim & Leclair is sold in the local bazaar in Türkiye. This popular wild-grown edible mushroom is locally called "*Kanlıca*", "*Melki*" and "*Çıntar*". *L. semisanguifluus* is preferred by local people for its aroma and taste. These properties, along with its comparatively easy availability, makes *L. semisanguifluus*

one of the most sought mushrooms for human consumption. Since mushrooms are collected for human consumption as a food, it is required to know the best storage forms (due to their short shelf life) as well as their nutritional value. Within this scope, the objective of this study is to determine the changes in the chemical composition (moisture, ash, crude protein, fat, and macro-micro mineral matters), and the carbohydrate content and energy values of the *L. semisanguifluus* treated with different processes (drying, canning, and freezing).

2. Materials and Methods

2.1. Materials

2.1.1. Sample collection

A total of 20 kg *L. semisanguifluus* were collected from Keles, Bursa in Türkiye (39°52′N 29°12′E). The *Figure 1* shows the photograph of the *L. semisanguifluus*. The altitude of this location is 1200 m which is the neighbour of Uludag mountain. The forest in the area where the mushrooms are collected; it consists of pine, oak, hornbeam, hawthorn, and occasionally poplar and plum trees. When the mushrooms were collected, it was noted that they were in the same maturity levels with the uniform shape, size, and health conditions to provide homogeneity.

Figure 1. Surface and inside photograph of the L. semisanguifluus

2.2. Methods

2.2.1. Preparation of samples

In this study, the *L. semisanguifluus* samples were prepared according to Aydin et al. (2017). Drying, canning, and freezing processes were applied to *L. semisanguifluus*. The mushroom samples were harvested with their pileus and stipe. After the cleaning treatment, the mushrooms were wiped on blotting paper to remove excess water and then sized. Only the pileus of the mushrooms was used which was the similar size. Before applying any process, the moisture, ash, crude protein, fat, carbohydrate and energy value of the fresh mushrooms were analysed. After these analyses, for the first step (drying), the mushrooms were dried at +40º C for approximately 24 h in a hot air oven dryer, as described by Aydin et al. (2017). Then, they were ground together in a coffee grinder (MKM6, Bosh, Germany) and sieved through a 60 mm sieve to obtain the mushroom powder. All the mushroom powder was stored in glass jars and kept in +4º C prior to analysis. In the second step canning was applied, as described by Aydin et al. (2017). The cleaned and cut mushrooms were boiled in boiling water for 30 minutes. After 30 minutes, the mushrooms were drained and put into glass jars while the mushrooms were still hot. Jar caps were closed immediately and the samples were allowed to rest while cooling so that the mushrooms could be kept safe until the analyses. The last step (freezing) was applied, as described by Barros et al. (2007b). After cleaning and cutting procedures, the mushrooms were put into freezer bags and stored at -20º C prior to analysis.

2.2.2. Morphological properties of samples

To determine the morphological properties of *L. semisanguifluus*, the pileus width (cm) and stipe length (cm) of the mushrooms were measured with a ruler, and the stipe diameter was measured with a calliper. In order to weigh the mushrooms (g), the analytical balance was used.

2.2.3. Colour properties of samples

Colour values were read with a chromameter (Konica Minolta CM-3600d, Japan). Before the measurement, the standard white plate was used to calibrate it. The measurement procedure was applied not only to the pileus surface

but also to the pileus inside of the fresh, dried and frozen samples. The colour measurements were performed on 30 mushroom samples and the average of the measurement results was given. According to the measurement results, *L** means the lightness of the mushroom and ranges from black to white (0-100). A negative value of *a** indicates green, while *a** positive number indicates red-purple colour. A positive *b** value indicates yellow, while a negative *b** value indicates blue (Nakılcıoğlu-Taş and Ötleş, 2020).

2.2.4. Chemical properties of samples

The moisture, ash, crude protein, and fat contents of the fresh and processed samples were determined according to the AOAC Method No: 930.04, 930.05, 978.04 (Nx6.25), 945.16, respectively (AOAC, 1990). The total carbohydrate content was estimated by using the Equation (Eq.) 1 (FAO, 2003):

$$\text{Total Carbohydrate} = 100 - [\text{Moisture (g)} + \text{Ash (g)} + \text{Protein (g)} + \text{Fat (g)}] \quad \text{(Eq. 1)}$$

The total energy value was calculated according to the Eq. 2 and Eq. 3 (Italian Law, 1993):

$$\text{Total Energy (kcal)} = 4 \times [\text{Protein (g)} + \text{Carbohydrate (g)}] + 9 \times [\text{Fat (g)}] \quad \text{(Eq. 2)}$$

$$\text{Total Energy (kJ)} = 17 \times [\text{Protein (g)} + \text{Carbohydrate (g)}] + 37 \times [\text{Fat (g)}] \quad \text{(Eq. 3)}$$

2.2.5. Mineral composition of samples

The macro and micro mineral contents (Na, K, Mg, Ca, P, Fe, Mn, Cu, and Zn) of the samples were designated by inductively-coupled plasma-optical emission spectrometry (ICP-OES) (3100XL; Perkin Elmer Optima, San Jose, California, USA) according to Sarıkurkcu et al. (2012).

2.2.6. Statistical analyses

The obtained results were subjected to statistical analysis. For this purpose, JMP IN 7.0.0 (SAS, Cary, North Carolina, USA) software was used. The data were presented as the mean ± standard deviation of three replicates. When significant differences were determined ($p < 0.05$), the least significant difference (LSD) test and analysis of variance (ANOVA) was used to identify the differences among the means. Dendrogram graphics were also created for some analyses, to identify groups that are close to each other were determined. For this purpose, the Hierarchical Clustering Method-Wards technique run in the JMP In 7.0.0. In the graphics, the colours indicate that from the smallest to the largest in blue, grey, and red colour tones from light to dark.

3. Results and Discussion

3.1. Physical properties of samples

3.1.1. Morphological properties of samples

In order to examine the morphological properties, 30 mushroom samples were used. All measurements were given in *Table 1*. For this purpose, firstly, analyses were made to measure the weight, pileus width, stipe length and stipe diameter (38.46 g, 8.61 cm, 2.99 cm and 2.67 cm, respectively) of the clean mushroom samples. These results are similar with those reported by Peksen and Karaca (2000) who found the mushroom weight as 31.43 g, the pileus width as 8.62 cm and the stipe length as 2.60 cm.

Table 1. The morphological properties of wild edible mushroom L. semisanguifluus*

Sample	Mushroom Weight (g)	Pileus Width (cm)	Stipe Length (cm)	Stipe Diameter (cm)
Fresh	38.46±0.75	8.61±1.06	2.99±1.18	2.67±3.42

**** Number of samples=30***

3.1.2. Colour properties of samples

In order to observe the colour values visually in more detail, the colour value results *L. semisanguifluus* by sample type are given in *Figure 2*. Fresh, canned, and frozen mushrooms colour value was characterized not only by the colour of the pileus surface but also by the inside of the pileus. The pileus surface of the fresh samples was found significantly higher ($P<0.05$) in *L** value as compared to those of the other samples indicating a lighter colour. The lower *L** values for the canned samples indicated a darker colour than the other samples. On the other

hand, the whole parts of the samples were used for the detection of the colour value of the dried samples. In the dried samples; *L**, *a** and *b** values were observed as 43.78±0.09, 6.61±0.10 and 20.35±0.07, respectively.

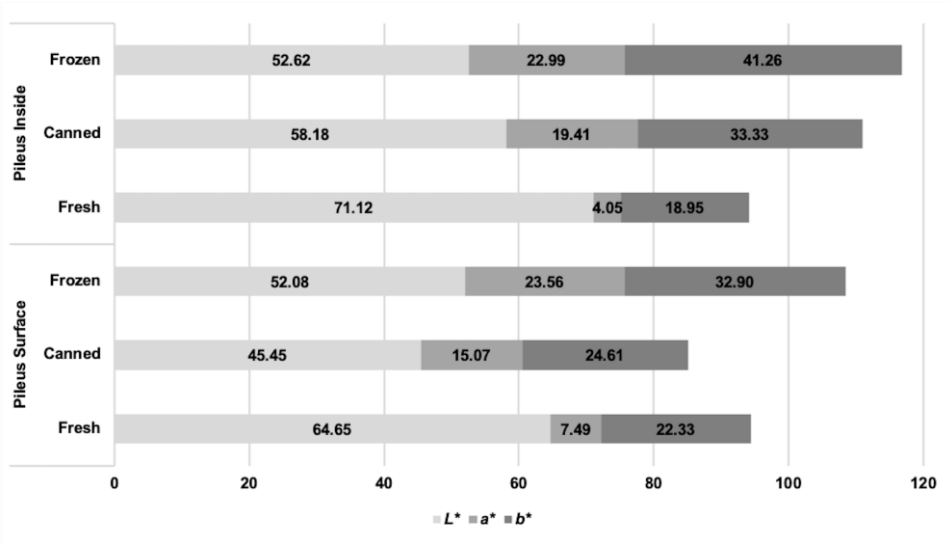

Figure 2. Colour value results of L. semisanguifluus by sample kind

**L*: Lightness of the sample, 100=white, 0=black; **a*: Redness when the values are positive and greenness when the values are negative; **b*: Yellowness when the values are positive and blueness when the values are negative.

L. semisanguifluus has a remarkable orange yellow colour. As reported by Kalac (2013) compared to plants, mushrooms lack chlorophyll and anthocyanins, and carotenoids are not common in mushrooms. Noticeable colour differences, mostly darkening, appear in some types after the mechanical damage of fruit body tissues. These kinds of changes are usually caused by enzymatically catalysed oxidation of different polyphenols to quinones.

The frozen mushroom samples were statistically higher (P<0.05) in *a** values than the fresh and canned mushrooms. These results showed that the frozen mushrooms had a redder pileus surface. The *b** values of the frozen samples are significantly higher (P<0.05) than the fresh and canned samples. When the inside colour of the pileus of the fresh samples was examined, they were found to be significantly higher (P<0.05) in *L** value. The canned and frozen samples had similar colours inside their pileus; they appeared to be darker than the fresh mushroom samples. The fresh mushrooms had significantly lower *a** and *b** values inside their pileus. As a result of the drying process, the dried samples lost lightness and had lower *L**, *a** and *b** values than the fresh, canned, and frozen samples. A similar result was also found by Peksen and Karaca (2000) who determined the *L**, *a** and *b** values as 42.03, 2.15 and 16.44, respectively.

3.2. Chemical properties of samples

Table 2 demonstrate the results of the physicochemical properties of the *L. semisanguifluus*. The moisture content ranged between 8.86% to 90.43 in all the samples. As expected, the dried mushroom samples had significantly (P<0.05) lower (8.86%) moisture value than the other samples due to the processing method. By contrast, the canned mushroom samples had the highest (90.43%) moisture value; however, there were no significant differences (P<0.05) between the fresh, canned, and frozen samples. In the presented research, the mean result for moisture value was found to be 89.57% (not including the dried sample results). This data was almost the same as the one reported from Greece on *L. semisanguifluus* as 89.59% (Jedidi et al., 2017). Owing to the dehydration process, the moisture content of the dried samples was detected very low (8.86%). The aim of the drying process of agricultural products; is to prevent the formation of biochemical reactions and the development of microorganisms in the product by removing the free water in the fresh product (Karacabey et al., 2020). Dried products are among the important processed foods because they have long storage periods (Şahin et al. 2012).

Table 2 shows the ash contents of the samples. The highest value of the ash content was found in the dried samples (5.94%), while the ash content of the other samples ranged from 2.79% to 4.75 %. The values within all

the samples showed significant differences (P<0.05). Kalac (2013) reported that the ash content of mushrooms ranged between 6-12% dry weight (dw). The amount of ash in the current study was observed to be below this value. The ash quantity was found to be 5.94 only in the dried samples. Similar ash contents (5.90%) of *L. semisanguifluus* were found in fresh and frozen samples by Kalogeropoulos et al. (2013).

Table 2. Chemical properties of fresh and processed L. semisanguifluus*

Sample	Moisture (%)	Ash (%)	Crude Protein (%)**	Fat (%)
Fresh	89.86±0.14^{a}	4.75±0.32^{ab}	3.34±0.42^{b}	1.20±0.40^{b}
Dried	8.86±0.06^{b}	5.94±0.72^{a}	18.53±0.08^{a}	7.99±0.17^{a}
Canned	90.43±0.15^{a}	2.79±0.05^{c}	1.21±0.27^{d}	0.53±0.05^{c}
Frozen	88.42±2.80^{a}	3.99±0.18^{bc}	2.25±0.12^{c}	0.65±0.02^{c}

*Estimated dry weight basis

** Protein conversion factor Nx6.25

Mean values represented by the same letters within the same column are not significantly different at P<0.05.

Data are expressed as means ± standard deviations (n=3).

The protein levels of the samples were demonstrated in *Table 2*. According to the results, compared with the fresh, frozen, and canned samples, the dried samples had the highest concentration of protein (18.53%). This fact might be partially due to the decrease in the moisture value. The protein content of the fresh mushrooms was found to be approximately 1.5 and 2.5 times higher than that of the canned and frozen samples. The values within all the samples showed statistically significant differences (P<0.05). Jedidi et al. (2017) reported the level of crude protein in *Lactarius deliciosus* as high as 18.09% dw, which was similar to our results. The protein contents of the other samples were estimated using the fresh samples. The fresh samples had the highest concentration of protein (3.34%), followed by the frozen (2.25%) and canned (1.21%) samples. Barros et al. (2007b) reported that while the boiling procedure could cause an important reduce in the protein content of the mushroom, the protein content remained almost stable during air-drying. 1.58% protein content was found in the freeze-dried *L. samisanguifluus* by Kalogeropoulos et al. (2013). Barros et al. (2007a) reported in another study that *T. portentosum* and *L. giganteus* had high protein levels (2.12%, 3.40%, respectively). As reported by Mendil et al. (2005) dried mushrooms had 17.5% protein content. This is similar to the protein content of the dried samples which were measured in this study. As expected, the drying procedure considerably increased the nutritional components ratio by decreasing the water content. In spite of that, if values are estimated on a fresh basis, lower ash, crude protein, and fat contents can be observed. The same results were observed in other studies which focused on different mushroom types (Manzi et al., 2004). On the other hand, Bano and Rajarathnam (1982) reported that protein contents of mushrooms depended on the compound of the substratum, size of pileus, harvest time, and species of mushrooms.

As can be viewed in *Table 2*, the fat concentration of the canned (0.53%) and frozen (0.65%) samples had nearly the same values. These results showed that the fresh samples had higher fat value (1.20%) than the other samples. According to these results, the process of canning and freezing decreased the fat content approximately in half. The same pattern was observed by Kalogeropoulos et al. (2013) who found out that the freeze-dried *L. samisanguifluus* samples had low fat (0.39%) content. In the study published by Barros et al. (2007a) it was reported that wild mushrooms, in general, had a lower quantity of fats compared to commercial mushrooms. *Figure 3A* shows the results of the cluster analysis of the chemical composition of the samples. According to the graphics processed mushrooms were divided into two group. Assessing on the chemical content, including the frozen samples, the fresh and canned samples were in a same group, differently than the dried samples. As expected, the chemical characteristics of the dried samples were intensive than the other group.

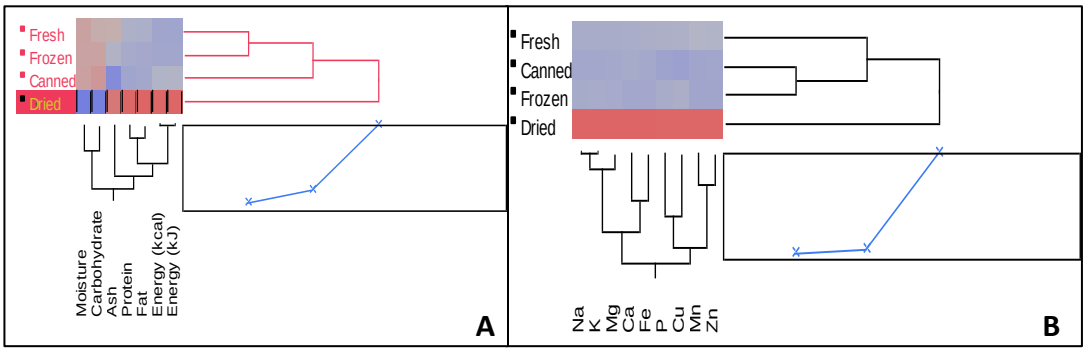

Figure 3. Hierarchical Clustering Analysis-Dendrogram for all processed wild grown edible mushroom samples concerning the content of (A) chemical analyses, (B) macro and micro mineral contents.

The carbohydrate contents and energy values of *L. semisanguifluus* are shown in *Table 3*. The highest level of carbohydrate was observed in the dried samples (58.68%), followed by the canned (4.69%) and frozen (5.03%) samples. The values within all the samples showed statistically significant differences ($P<0.05$). Kalogeropoulos et al. (2013) also declared the carbohydrate content as 7.88% in their study.

Table 3. Distribution of carbohydrate contents and energy values by processing kind of sample

Sample	Carbohydrate (%)	Energy (kcal $100g^{-1}$)	Energy (kJ)
Fresh	0.85 ± 0.18^{c}	27.56 ± 2.49^{b}	115.63 ± 3.12^{d}
Dried	58.68 ± 1.55^{a}	380.75 ± 1.32^{a}	1608.20 ± 5.41^{a}
Canned	4.69 ± 0.07^{b}	33.61 ± 4.92^{b}	142.03 ± 2.97^{b}
Frozen	5.03 ± 0.03^{b}	29.82 ± 0.13^{b}	126.06 ± 4.88^{c}

Mean values represented by the same letters within the same column are not significantly different at $P<0.05$. Data are expressed as means ± standard deviations (n=3).

The energy value (*Table 3*) was found to be significantly higher in the dried samples than the other samples. The energy values of the fresh, canned, and frozen samples were similar and statistically non-significant. While the energy value was found to be lowest in the fresh samples with a value of 27.56 kcal $100g^{-1}$, the highest energy value was found in the dried samples (380.75 kcal $100g^{-1}$). With the exception of the dried samples, similar results were found by Kalac et al. (2009). It was also reported by Kalac (2009) that low dry matter and lipid contents resulted in low energy values of mushrooms.

As reported by Barros et al. (2007a), wild mushrooms are good sources of protein and have low amounts of fat, making them an ideal foodstuff. Compared to their protein and carbohydrate contents, mushrooms have a very low-fat content (Wani et al., 2010). Likewise, the high protein, carbohydrate, and low-fat ratio of edible wild mushrooms have been previously evaluated by other researchers (Diez and Alvarez, 2001). Being a rich source of protein and carbohydrate content, they fall between most legumes and meat (FAO/WHO, 1989) and can be a perfect substitute food used in low-calorie diets for their low contents of fat and energy (Barros et al., 2007a).

The macro and micro mineral compositions of the samples are displayed in *Table 4*. According to the results, the most abundant macro mineral was found to be K, (ranging from 108.6 mg $100g^{-1}$ to 2367.4 mg $100g^{-1}$ dw), followed by P, Mg, and Na. As mentioned in the last research, it was reported that mushrooms contained a wide ratio of mineral components, particularly P and K (Barros et el., 2007b).

The Fe element (0.58-9.4 mg $100g^{-1}$) was detected as the most abundant micro mineral in the samples. On the other hand, the micro minerals (Fe, Cu, Zn, and Mn) were found to be statistically ($P<0.05$) similar in the canned and frozen samples. Aloupi et al. (2012) reported that *L. semisanguifluus* contained Fe, Cu, Zn, and Mn (0.48 mg $100g^{-1}$, 0.93 mg $100g^{-1}$, 7.04 mg $100g^{-1}$, and 0.51mg $100g^{-1}$, respectively). The amounts of mineral contents vary according to the species, age, and the diameter of the fruiting body (Wani et al., 2010). According to the Food and Drug Administration (FDA), the daily intake of macro minerals should be 4700, 1250, 1300 and 420 mg for K, P,

Ca and Mg elements, respectively. This amount should be 11, 18, 2.3 and 0.9 mg for the micro elements Zn, Fe, Mn and Cu, respectively (Anonymous, 2019). Considering these amounts, it is seen that especially the dried mushroom investigated in this present study provides an important part of the daily macro and microelement needs.

Table 4. Macro and micro mineral composition of fresh and processed L. semisanguifluus

Samples	Macro Minerals (mg 100g^{-1})				
	Na	**K**	**Mg**	**Ca**	**P**
Fresh	7.78±1.8^{b}	244.5±1.8^{b}	12.0±6.0^{ab}	4.19±2.1^{b}	57.5±3.9^{b}
Dried	38.0±2.1^{a}	2367.4±9.9^{a}	13.50±1.2^{a}	21.2±4.1^{a}	182.7±7.5^{a}
Canned	5.84±2.1^{c}	108.6±2.6^{d}	5.79±1.6^{c}	3.8±5.5^{bc}	37.4±1.8^{d}
Frozen	7.15±1.2^{b}	221.9±1.9^{c}	9.70±1.6^{b}	3.0±2.1^{c}	52.6±5.3^{c}
Samples	**Micro Minerals (mg 100g^{-1})**				
	Fe	**Mn**	**Cu**	**Zn**	
Fresh	1.27±0.9^{b}	0.23±0.11^{b}	0.21±0.04^{b}	0.71±0.64^{b}	
Dried	9.4±2.6^{a}	0.79±1.41^{a}	0.58±0.71^{a}	3.92±3.9^{a}	
Canned	0.65±2.1^{c}	0.12±0.05^{c}	0.13±0.07^{c}	0.18±0.57^{c}	
Frozen	0.58±1.2^{c}	0.12±0.07^{c}	0.17±0.06^{c}	0.14±0.47^{c}	

Mean values represented by the same letters within the same column are not significantly different at ($P<0.05$). Data are expressed as means ± standard deviations (n=3).
All the mineral concentrations were determined on a dry weight basis.

According to the results of the dendrogram graphs (*Figure 3B*), based on the mineral content, the canned and frozen samples showed similar characteristics. The dried mushrooms were in a different group than the other samples. Various authors reported that wild edible mushrooms were highly nutritional and were compared extremely with meat, egg, and milk (Adejumo and Awosanya, 2005). Accordingly, people living in rural areas believe that wild mushroom has an equal nutritional value with meat. As a result, despite the fact that wild mushrooms grow spontaneously in many regions of Turkey, they should be consumed carefully. It is very important to know the edible species in terms of human health.

4. Conclusions

Due to the mushrooms lose their quality immediately after harvest, it requires some process to prevent its deterioration. In this study, the changes in the chemical and nutritional values as well as morphological properties of *L. semisanguifluus*, the wild-grown edible mushroom which was treated with different processes, were determined. According to the results, all processing techniques influenced the nutritional value of the mushroom. In present study, the drying method significantly increased the nutrient concentration by decreasing the water content. The freezing and canning procedures revealed poor decreased chemical results compared to the fresh samples. The results of the present study indicated that in order to protect the nutritional properties of mushrooms, the freezing process is the best protection technique rather than the canning process, and consequently recommend frozen mushrooms, which are frozen under suitable conditions, in terms of nutritional value. In conclusion, due to its functional properties, high nutritional values, low contents of fat and energy, and the composition of mineral matter, *L. semisanguifluus* is an excellent food that can be suitable for use in the diet with its functional compounds, and other nutritional values. The canned and frozen mushrooms can be used to prepare the meal in that shape and that dried mushroom can, however, be milled as a flour and can be used to production of some food such as biscuit, cracker, bread, noodle, snack and chips as an additive which would help take advantage of its nutritional values. It was concluded that *L. semisanguifluus* can be processed with different techniques and can be used not only for household consumption but also in food industry.

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