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Research article

Evaluation of nutritional composition and health benefits of three edible mushrooms

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Abstract: This study was to examine the fatty acid profile and detect some major elements which these nutritional components are crucial and helpful to the human health system. The study samples three wild-grown edible mushroom species Tricholoma terreum (Schaeff.) P. Kumm., Marasmius oreades (Bolton) Fr. and Coprinus comatus (O. F. Müll.) Pers. were collected from the Tokat region and detected 8 different fatty acid levels and major elements such as Fe, Cu, Mn, and Zn. Among these varieties of fatty acids; the highest levels of Palmitic, stearic, linoleic and oleic acids were determined. Palmitic acid was detected in 16.43-34.15%, stearic acid 16.73-50.24%, linoleic acid 28.19-32.40% and oleic acid 15.35-18.10% across all samples. These ranges of fatty acids are important for preventing or reducing the risk of cardiovascular disease, metabolic syndrome, Alzheimer's disease and many biological activities. When we compared the study samples according to the number of fatty acids they contained; Coprinus comatus species had the highest percentages of myristic, pentadecanoic, palmitic, palmitoleic and linolenic (which as called Ω3) and their percentages were respectively, 1.48, 0.41, 34.15, 3.02, and 0.67%. In addition, stearic and linoleic acid ranges were 32.40-50.24% seen at Tricholoma terreum, and the highest range of oleic acid was detected at Maramius oreades. Besides, major minerals like zinc, iron, manganese and copper were measured in very high concentrations. Marasmius oreades had the highest element levels, Fe and Cu, whereas Coprinus comatus had Mn and the last of Tricholoma terreum had Zn elements. When we ask why minor or major elements are important because of, they are healthy for the human neurologic, hepatic, and skeletal systems and they act as immunomodulators. The highest amount of mineral in study samples belonged to zinc and its range was detected to be 152.40-416.40mg/kg, secondly was iron and its range was 86.16-478.00mg/kg. The highest copper level was detected in Marasmius oreades as 72.20 mg/kg and the highest manganese was 57.24 mg/kg in Coprinus comatus. The study aims to prove that these mushroom species can be able to stock a very high quantity of minerals that are macro minerals, and vital fatty acid varieties. We can say that these wild edible fungus specimens can be improved and used as human nutritional supplements by looking at their fatty acid profiles and mineral content.

Keywords: Fatty acids, Minerals, Edible mushrooms, Türkiye

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Introduction

Mushrooms have been historically used since ancient times. They have been known and used in very different ways for human health and when they became known, their importance increased for humanities. Their use has expanded up to have been used for pharmaceutical, nutraceutical, economic and cosmeceuticals for humankind to be developed to improve their areas of use and make it beneficial for human health. According to estimates based on literature data; mushrooms have a diversity of about 12000 species worldwide, of which about 2000 have been recorded as edible. About 35 edible species can be cultivated commercially, but only about 200 wild species can be used for medicinal purposes (Ayaz et al., 2011; Baum et al., 2012; Beulah et al., 2013; Demirbaş, 2001; Gençcelep et al., 2009; Konuk et al., 2007).

Literature data have established that edible mushrooms can contain various nutraceutical compounds such as low calories, fatty acids, vitamins, protein, minerals, dietary fibre, peptides, glycoproteins, antioxidants such as phenolic and flavonoid compounds, etc. (Barros et al., 2007; Florczak et al., 2004; Hugges and Sammon, 2006; Pardeshi and Pardeshi 2009). Therefore, edible mushroom species have been the focus of researchers' interest and they provide and select specific bioactive compounds. These compounds act as biological activities such as antioxidant, antibacterial, antifungal, anti-immunomodulatory, antitumour, anti-inflammatory and cytotoxic effects (Komura et al., 2010; Turkoglu et al., 2007; Zhangi et al., 2007). In addition, the presence of important compounds makes these mushrooms therapeutically valuable resources ranging from the strengthening of the immune system to the cure and prevention of serious diseases such as hypertension, heart disease, cancer, Alzheimer's disease, stroke and nervous disorders (Kavishree et al., 2008; Kim et al., 2005; Kivipelto and Solomon, 2006; Shabab et al., 2007). Lipids are essential biological molecules in cell structure and metabolism, lipids are more important in energy storage than caloric energy, protein or carbohydrates (Hugges and Sammon, 2006; Kalac, 2009). Lipids perform important functions as critical structural components of biological membranes, provide readily available energy reserves, and serve as essential vitamins and hormones, but also aid in the solubilisation of dietary lipids in human health and physiology (Pardeshi and Pardeshi, 20098; Wasser and Weis, 1999; Zhangi et al., 2007).

Mushrooms could accumulate and form important minerals from the soil conditions of their habitats. Some minerals are called major, essential and minor elements, but human body needs these major or minor elements and has to get some form of nutrition so mushroom becomes important at this point. Some of these major elements are listed as Fe, Zn, Mn, Na, Ni, Mg, Al, K, Ni and Zn and they act as immunomodulator, regulator for life element cycle system, haematopoietic agents etc. (Barros et al., 2008; Manzi et al., 2001; Mleczek et al., 2021). Iron is an essential element for humans and other living organisms and functions as an integral part of haemoglobin and myoglobin, and it also functions in the critical roles of oxygen delivery to tissues and energy conversion. Zinc is also required for the enzymes involved in metabolic activities such as the release of carbon dioxide from tissues into the lungs, the synthesis of protein, DNA and RNA, and carbohydrate metabolism. Copper plays an important role in the formation of collagen and the synthesis of haemoglobin with iron. It is also involved in skeletal development, the immune system and melanin production. In addition, manganese acts to activate a wide range of enzymes such as decarboxylases, kinases and transferases. It performs biochemical oxidative phosphorylation, fatty acid metabolism, protein synthesis and cholesterol (Anderson and Cockayne, 2003; Beulah et al., 2013; Wasser and Weis, 1999).

In many countries, fungi are consumed as a natural food source and are of great importance due to their high nutritional, medicinal and economic value. Turkey has a remarkably rich diversity of wild edible mushroom species and a high potential for consumption and export of edible mushrooms. The urban population uses some of the known edible species in Turkey, but not every wild edible mushroom species is known. Therefore, many more edible mushroom species should be introduced to people with benefits. With this study, we want to introduce some wild edible mushroom species that have a very high level of fatty acids and minerals that are very important for the human body.

According to the results of this study, more awareness has been created about these mushroom species and their availability as dietary supplements has been proposed.

Material ve Methods

The mushroom species were collected from different localities from Tokat in Turkey. The habitat and macroscopic properties were noted and photographed. The samples were brought to the laboratory and described (Breitenbach and Krazlin, 2000; Bresinsky and Besl, 1990; Knudsen and Vesterholt, 2008, 2012; Phillips, 2006).

The process steps of microwave digestion systems and AAS (Atomic Absorption Spectrometer) analysis

MARS 6 ONE-TOUCH (CEM-USA) model equipment is used for the microwave digestion system. Before this, the samples are weighed as 0,5 gr and filled up to teflon tubes of the device, then added 10 mL HNO_3 and close the mouth tightly. The method is chosen which record before at the device was. The temperature is increased about max 210 C̊ at 15 minutes and waits during this time. The total time is 30 minutes and the device works with 1800W and giving to the AAS (Perkin Elmer, AAS 800 model, USA) device. In this device, each sample is read with hollow cathode lamp, wavelength and standard graphics which are the specifications for each element, then samples are read 3 times and the average levels is taken for each.

The process steps of GC-MS and preparing the samples

Hara and Radin (1978) method for lipid extraction from ground mushroom samples was used revised. For this, the plant sample was homogenized in 10 mL of hexane / isopropanol (3: 2) and centrifuged at 5000 rpm for 10 min (Hara and Radin, 1978). The organic phase was removed and placed in the test tubes. Fatty acids need to be derivatized in order to be able to look at GC. Derivatization with methyl esters was often preferred. For this purpose, Christie (1990) method was preferred because it is practical and highly efficient. According to this method; the lipid extract prepared above was taken out of the mouth-capped tubes to prepare methyl esters. 5 mL of 2% methanolic sulfuric acid was added and vortexed. This mixture was left to stand for 15 hours of methylation at 50 °C. At the end of this period, the tubes were removed, cooled to room temperature, and vortexed with the addition of 5 mL of 5% NaCl. The fatty acid methyl esters (FAME) formed in the tubes were extracted with 5 mL of hexane and the hexane phase was taken up from the top and treated with 5 mL of 2% NaHCO3 and waited for 2 hours to separate the phases. The solvent of the mixture containing the methyl esters was then evaporated under nitrogen at 45 °C and the fatty acids below the test tubes were dissolved in 1 mL of hexane and analyzed by GC-MS using amber GC vials.

The chromatographic conditions of the GC-MS instrument are as follows

Agilent brand 7890A / 5970 C model GC-MS instrument (USA) and SGE Analytical BPX90 100m x 0.25 mm x 0.25 um column (Australia) was used for the GC-MS analysis. The temperature program was regulated as step by step from 120 °C to 250 °C and the total time is set to 40 minutes which is heated up to 120 °C and 250 °C at 5 °C / min and is held at this temperature for 14 minutes. The program automatically set the injection volume 1µL and split ratio is 20:1, solvent delay time is 12 minutes, carrier gas He is selected and constant gas flow is set at 1mL/min, H_2 flow 35 mL/min, dry air flow 350 mL/min and N_2 20.227 mL/min. The results of GC-FİD and MS are recorded simultaneously and are a comparison to NIST and WHILEY libraries data which are registered on the device.

Results

Samples were collected from different habitats in Tokat province and dried under laboratory conditions. The samples were analysed using AAS and GC-MS methods. The study measured the amounts of iron, copper, manganese and zinc, which are major elements, as well as eight different types of fatty acids.

The mineral contents of the samples were major minerals and it was found that all 4 types of elements were present in high amounts. The highest values of each mineral among the species; 478.00 mg/kg iron and 72.240 mg/kg copper values were measured in *Marasmius oreades,* the highest manganese value of 57.240 mg/kg was measured in *Coprinus comatus* and finally the amount of zinc of 416.40 mg/kg was measured in *Tricholoma terreum* (Figure 1)). The lowest amounts of minerals, usually 86.160 mg/kg of iron, 37.36 mg/kg of copper and 7.92 mg/kg of manganese, were found in the *T. terreum* species, while the lowest zinc value was found in *C. comatus* with 152.40 mg/kg. The mineral contents of the species are given in Table 1.

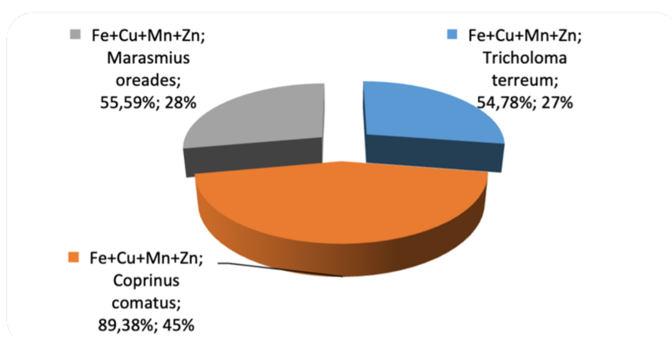

Figure 1. Percentage ratios of minerals

Table 1. Mineral amounts of species (were measured mg/kg^{-1})

Mushroom species	Fe	Cu	Mn	Zn
Tricholoma terreum	86.160	37.360	7.920	416.400
Marasmius oreades	478.000	72.240	47.640	275.960
Coprinus comatus	295.680	50.640	57.240	152.400

Another data from our study was the detection of 8 different fatty acids. These fatty acids are myristic, pentadecanoic, palmitic, palmitoleic, stearic, oleic, linoleic and linolenic. Among the fatty acid types, if we look at the percentages of these three types, the most abundant ones, palmitic, stearic, linoleic and oleic acids are found in high amounts in all types (Table 2). Types of study according to the highest content of fatty acids; *C. comatus*, high myristic, pentadecanoic palmitic, palmitoleic and linoleic types *T. terreum* in search of stearic and linoleic acid are a high ratio, while *M. oreades* only when it is observed that oleic acid was found to have the highest. When we studied the species in terms of MUFA, PUFA and SFA content, the highest SFA content was found in *T. terreum* with 67.34%, the highest MUFA content was found in *M. oreades* species with 18.70% and finally the highest PUFA content was found in *Tricholoma* species with 32.40% (Figure 2).

Table 2. Fatty acid profiles of mushroom samples (as %) (C14: Miristic, C15: Pentadecanoic, C16: Palmitic, C16:1: Palmitoleic, C18: Stearic, C18:1: Oleic, C18:2: Linoleic, C18:3: Linolenic)

	Tricholoma terreum	*Marasmius oreades*	*Coprinus comatus*
C14:0	0,36	0,49	1,48
C15:0	0,31	0,00	0,41
C16:0	16,43	32,96	34,15
C18:0	50,24	18,87	16,73
C16:1	0,26	0,60	3,02
C18:1	0,00	18,10	15,35
C18:2	32,40	28,98	28,19
C18:3	0,00	0,00	0,67

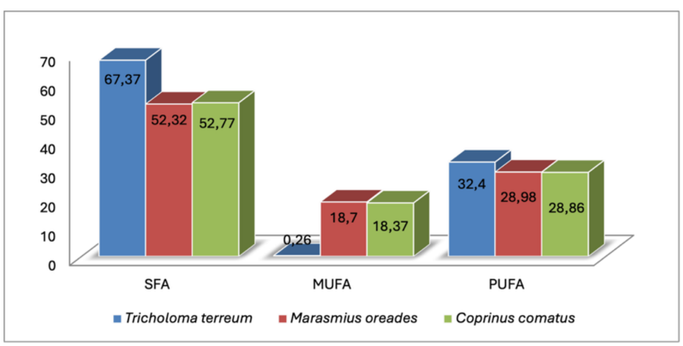

Figure 2. SFA; Saturated fatty acid (C14,C15,C16,C18), MUFA; Monounsaturated fatty acids (C16:1,C18:1), PFA:Poliunsaturated fatty acids (C:18:2,C18:3)

Discussion

According to the major mineral contents selected in our study (Fe, Cu, Mn and Zn), T. terreum species has approximately 54% of these major type contents, while *M. oreades* species has 89% and *C. comatus* species has the lowest 55% of these major minerals. In the research samples, other major and minor minerals were found in percentage proportions of mineral content (Figure 1).

Mushrooms contain 20-30 g of different fatty acids in their dry weight. These fatty acids are classified according to the number of carbon atoms and double bonds they contain. They are divided into three groups: saturated, monounsaturated and polyunsaturated fatty acids. Saturated fatty acids (SFA) are classified as C14,15,16,18, while monounsaturated fatty acids (MUFA) are divided into C16:1 and C18:1, and polyunsaturated fatty acids (PUFA) are divided into C18:2 (W-3) and C18:3 (W-6) (Pompili et al., 2017). In the 1950s, studies suggested that consumption of SFA increased low-density lipoprotein cholesterol (LDL-C). However, more recent studies suggest that MUFAs and PUFAs are essential for heart health (Baum et al., 2012). According to literature, PUFA intake could be used as an inflammatory biomarker for cardiovascular disease and could be useful for secondary prevention of dietary patterns (Bercsch-Ferreira et al., 2017; Beulah et al., 2013).

The study included samples with different levels of MUFA, PUFA and SFA. The highest level of SFA was observed in *T. terreum* at 67.34%, while the other species had levels close to 52%. *Marasmius* and *Coprinus* had the highest levels of MUFA at around 18%, while *Tricholoma* had the highest level of PUFA at 32.40%. *Marasmius* and *Coprinus* had similar levels of PUFA at 28.98% and 28.86% respectively (Figure 2).

Today, dietary supplements have become an important area of research. Scientists are investigating the essential elements and ingredients in these supplements to help diagnose, treat and prevent a range of diseases. Some studies suggest that changes in metabolites and lipid levels in the body are associated with the development of Alzheimer's disease. Fatty acids, which are biomolecules that contribute to cell structure, energy storage and signalling in neurons, are particularly important in this process. Neuronal membranes are mainly composed of polyunsaturated fatty acids, which make up about 50% of the total. Another conducted research that showed that SFA (saturated fatty acids) may be the most important biomarker for Alzheimer's disease, based on studies of patients of different ages and diets (Kivipelto and Solomon, 2006; Pompili et al., 2017; Shabab et al., 2005; Wang et al., 2012). Another research is about suicidal disorders and they suggested that increasing PUFA intake could be relevant in the treatment of depression, but there is no supporting data on the prevention of suicide cases (Pompili et al., 2007). Another study on fatty acids and metabolites in blood serum mentions that combinations of fatty acids can be used as determinants for some metabolic and cardiovascular disorders (Skeaff et al., 2006; Vessby et al., 2002; Yu et al., 2012). FA levels predict the long-term development of MetS, which is the metabolic syndrome, a cluster of abnormalities such as obesity, dyslipidaemia, hyperglycaemia and hypertension (Kabagambe et al., 2008; Warensjo et al., 2005).

Serum minerals such as zinc, iron and copper are associated with metabolic syndrome (MetS). Zinc has been shown to have a beneficial effect on total cholesterol and low-density lipoprotein cholesterol (LDL-C). In addition, some elements play an essential role as cofactors in fatty acid synthesis (Clejan et al., 1982; Mahfouz and Kummerow, 1989). The recommended daily intake of copper is 2-4 mg. Adults generally consume 1-2 mg of copper daily from food, while children aged 2 years consume 0.6-0.8 mg. Note that copper in drinking water is not included in these calculations. Copper is essential for a number of functions, including skin and hair colour, red blood cell production, metabolic processes and the immune system. Copper deficiency can lead to conditions such as anaemia, low immunity, eczema, and also acts as a cofactor for several essential enzymes. It also plays an important role in regulating angiogenesis, neurohormone release, oxygen transport and genetic structure. Excess copper can lead to atherosclerosis and cataracts, while it regulates the function of several enzymes and the work of the heart. Copper intake can also speed up the healing of broken bones (BruBe et al., 2007).

The human body contains 2-2.5g of zinc. More than half of this amount (55%) is found in the muscles, 30% in the bones and the rest in the blood, red blood cells, prostate, liver and pancreas. Zinc is only absorbed by the carrier effect and diffusion processes, which ensures that the element is more effectively absorbed in moderate (30%) and deficient conditions if it is ingested in sufficient quantities with the diet (BruBe et al., 2007; Chesters, 1997). The daily requirement of zinc is 6-15 mg. Deficiency can result in conditions such as poor development and dwarfism or short stature, anorexia, parakeratotic skin lesions, diarrhoea, loss of appetite, impaired testicular development, impaired immune function, impaired learning function, scaling of the skin, hair loss, delayed wound healing, frequent infections (Atabey, 2005; Gerald, 2005; Halilova, 2009; Shabab et al., 2005; Skeaff et al., 2006). Zinc is a common element in daily vitamin and mineral supplements. It is known for its antioxidant properties, which can prevent premature ageing of the skin and muscles (Aguilar et al., 2007; Anderson and Cockayne, 2003). Zinc is an essential component of at least 50 different enzymes and plays a vital role in their catalytic, co-catalytic or structural functions, mostly through histidine, glutamyl or aspartyl residues. Low levels of zinc in the body can increase the risk of osteoporosis and susceptibility to oxidative stress. However, excessive use of zinc supplements can interfere with copper metabolism and lead to copper depletion in the body. Continuous exposure to high levels of zinc (100 mg) can also reduce HDL cholesterol levels through immune function (Gerald, 2005). In 1982, the FAO/WHO and JECFA recommended that the daily requirement for zinc in the human body was 0.3 mg per kilogram of body weight. At the same time, JECFA set the maximum daily intake of zinc at 1 mg. The recommended daily intake of zinc for adults is 6-15 mg/day. It has been reported that drinking water containing more than 3 mg/l of zinc may have adverse health effects (Wang et al., 2012).

Manganese is a trace element that is required in the daily diet of humans at a level of 30-50 µg/kg body weight. This element is required for some enzymes involved in the process of carbohydrate metabolism. Although manganese is widely distributed in non-calcified tissues, with the highest concentration in the liver, little is known about its absorption, transport and uptake. The body needs an average daily intake of 2-5 mg of manganese, which is essential for activating antioxidant enzymes, metabolizing fat, making cartilage, detoxifying the body and keeping cells young. Deficiency can lead to weak bones, nerves and frequent infections. Although manganese is not very toxic, its intensive accumulation in tissues has been found to cause toxic effects in the brain and lungs and irreversible brain damage such as Parkinson's and Alzheimer's (BruBe et al., 2007; Shabab et al., 2005; Skeaff et al., 2006; Wang et al., 2012).

Iron is essential for the production of substances that give color to our blood and muscles, carry oxygen and produce enzymes that speed up metabolism and help conserve energy during high performance. Iron deficiency can lead to weakness, shortness of breath, jaundice, recurrent headaches, anemia, a habit of eating clay and ice, sleep disturbances, extreme fatigue, sunken nails, breakage and hair loss (Atabey, 2005; Gerald, 2005; Halilova, 2009; Mleczek et al., 2021). The human body typically contains 5 mg of iron, which plays a vital role in iron metabolism by transporting oxygen and electrons throughout the body. Iron is a redox factor that facilitates many enzyme reactions, including the oxidation and reduction of substrates. Men and women consume 6% and 13%, respectively, of their daily food intake as iron. However, in cases of severe iron deficiency, this percentage can rise to 50%. Chronic iron overload is mainly caused by a genetic disorder called haemochromatosis or a condition that requires frequent blood transfusions. A daily intake of 0.4-1 mg/kg body weight is considered safe for healthy people and is unlikely to cause any adverse effects. The accumulation of iron oxides in the lungs is called "siderosis" and is often seen in people who work in the iron and steel industry (Aguilar et al., 2007; Mleckzek et al. 2021; Shabab et al., 2005; Skeaff et al., 2006; Wang et al., 2012).

Table 3 shows the closest results from previous studies in the country that have examined mushrooms. The species *Marasmius oreades* had the highest content of iron and copper with 478.00 mg and 72.24 mg respectively. Meanwhile, the species *Coprinus comatus* had the highest level of manganese at 57.24 mg and the species *Tricholoma terreum* had the highest level of zinc at 416.60 mg. Although the results were high compared to the FAO/WHO criteria, the mushrooms in the study could still meet important mineral needs based on people's dietary habits and frequency of mushroom consumption.

Although these species are widespread, their edibility is not well known. However, this study demonstrates the potential health benefits of mushrooms whose medicinal properties are not yet fully understood.

Table 3. Comparison of the Literature data about the study samples

Comparison literature data	Mushroom Species	Fe	Cu	Mn	Zn
	Tricholoma terreum	86.160	37.360	7.920	416.400
Çınar Yılmaz 2021	*Marasmius oreades*	478.000	72.240	47.640	275.960
	Coprinus comatus	295.680	50.640	57.240	152.400
Şen et al., 2014	*Tricholoma terreum*	-	28.90	43.15	68.07
Dursun et al., 2006	*T. terreum*	4236.0	21.9	55.6	61.7
	Coprinus comatus	1354.8	48.7	24.0	51.6
Yılmaz et al., 2003	*T. terreum* from road side	741	25	19	179
	T. terreum background	1042	39	20	228
Gençcelep et al., 2009	*Marasmius oreades*	305	9.23	26.7	61.2
Işıldak et al., 2004	*M. oreades*	335	61.5	27.7	47.8
Işıldak et al., 2007	*T. terreum*	253.65	34.86	23.23	54.13
Sesli et al., 2008	*M. oreades*	150	30.5	13	135
Uzun et al., 2011	*M. oreades*	17	54	18.4	260
	T. terreum	49	77.2	12.3	17.02
Sesli and Tüzen, 1999	*M. oreades*	270	61.5	44.1	77.4
	C. comatus	264	71.4	12.3	32.0
Yamaç et al. 2009	*C. comatus*	3640	60.60	81.40	63.40
Tüzen et al. 2007	*T. terreum*	963	32.8	120	88.3

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Ethical Approval

No need to ethical approval for this study.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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References

Aguilar, M. V., Saavedra, P., Arrieta, F. J., Mateos, C. J., González, M. J., & Meseguer, I. M. C. (2007). M-P. Plasma mineral content in type-2 diabetic patients and their association with the metabolic syndrome. *Ann Nutr Metab,* 51(5), 402-6.

Anderson, S. C., & Cockayne, S. (2003). *Clinical Chemistry Concepts and Application*. McGraw-Hill, Medical Publishing Division.

Atabey, E. (2005). *Tıbbi Jeoloji Kitabı*, TMMOB Jeoloji Mühendisleri Odası, Yayın No:88, 194s, ISBN:975-395-844-7, Ankara.

Ayaz, F. A., Torun, H., Özel, A., Çöl, M., Duran, C., Sesli, E., & Colak, A. (2011). *Nutritional value of some wild edible mushrooms from Black Sea Region (Turkey).* Turkish J of Biochem., 36(3), 213-221.

Barros, L., Baptista, P., Correia, D. M., Casal, S., Oliveira, B., & Ferreira, I. C. F. R. (2007). Fatty acid and sugar compositions, and nutritional value of five wild edible mushrooms from Northeast Portugal. *Food Chemistry*, 105, 140-145.

Barros, L., Cruz, T., Baptista, P., Estevinho, L. M., & Ferreira, I. C. F. R. (2008). Wild and commercial mushrooms as source of nutrients and nutraceuticals. *Food Chemistry Toxicology*, 46, 2742-2747.

Baum, S., Kris-Etherton, P. M., Willet, W. C., Lichtenstein, A. H., Rudel, L. L., Maki, K. C., Whelan, J., Ramsden, C. E., & Block, R. C. (2012). Fatty acids in cardiovascular health and disease: A comprehensive update. *Journal of Clinical Lipidology,* 6, 216-234.

Bercsch-Ferreira, A. C., Sampaio, G. R., Gehringer, M. O., Ross-Fernandes, M. B., Kovacs, C., Alves, R., Pereira, J. L., Magnoni, C. D., Weber, B., & Rogero, M. M. (2017). Association between polyunsaturated fatty acids and inflammatory markers in patients in secondary prevention of cardiovascular disease. *Nutrition, 37*, 30-36.

Beulah, H., Margret, A. A., & Nelson, J. (2013). Marvelous medicinal mushrooms. *Int. J. Pharma. Bio. Sci.,* 3(1), 611-615.

Breitenbach, J., & Kränzlin, F. (2000). *Fungi of Switzerland. Volume 6. Russulaceae*. Verlag Mykologia, Switzerland.

Bresinsky, A., Besl, A. (1990). *A colour of atlas of poisonous fungi*. London.

BeruBe, K., Balharry, D., Sexton, K., Koshy, L., & Jones, T. (2007). Combustion-derived nanoparticles: mechanism of pulmoner toxicity. *Clinical and Experimental Pharmacology and physiology,* 34, 1044-50.

Clejan, S., Castro-Magana, M., Collipp, P., Jonas, E., & Maddaiah, V. (1982). Effects of Zinc deficiency and castration on fatty acid composition and desaturations in rats, *Lipids,* 17(3), 129-35.

Chesters, J.K. (1997). Zinc. In: O'Dell, B.L. and Sunde, R.A. Eds., *Handbook of Nutritionally Essential Mineral Elements,* Marcel Dekker Inc., New York, 185-230.

Demirbaş, A. (2001). Concentrations of 21 Metals in 18 Species of Mushrooms Growing in the East Black Sea Region. *Food Chemistry*, 75, 453-457.

Diez, A. A., & Alvarez, A. (2001). Compositional and nutritional studies on two edible mushrooms from Northwest Spain. *Food Chemistry*, 75, 417-422.

Dursun, N., Özcan, M. A., Kaşık, G., & Öztürk, C. (2006). Mineral Contents of 34 Species of Edible Mushrooms Growing Wild in Turkey. *Journal of the Science of Food and Agriculture,* 86, 1087-1094.

Florczak, J., Karmanska, A., & Wedzisz, A. (2004). A comparison of chemical composition of selected wild-growing mushrooms. *Bromatologia i Chemiczna Toksykologia,* 37, 365-370.

Gençcelep, H., Uzun, Y., Tuncturk, Y., & Demirel, K. (2009). Determination of mineral contents of wild-growing edible mushrooms, *Food Chemistry,* 113, 1033-1036.

Gerald, F. C. Jr. (2005). *Geological impacts on nutrition.* Medical Geology (Eds. O. Selinus, B. Alloway, J. A., Centone, R. B. Finkelman, R. Fuge, U. Lindh and P. Smedley), 7, 161-177.

Halilova, H. (2009). *Doğadan gelen sağlık,* Palme Yayınları: 492. 128s. ISBN:978-605-5829-02-5, Ankara.

Hara, A., & Radin, N. S. (1978). Lipid extraction of tissues with a low-toxicity solvent. *Analytical Biochemistry*, 9, 420-426.

Hughes, S., & Samman, S. (2006). The effect of zinc supplementation in humans on plasma lipids, antioxidant status and thrombogenesis. *J Am Coll Nutr,* 25(4), 285-91.

Işıldak, Ö., Turkekul, İ., Elmastaş, M., & Aboul-Enein, H. Y. (2007). Bioaccumulation of Heavy metals in some Wild-Grown Edible Mushrooms, *Analytical Letters*, 40, 1099-1116.

Işıldak, Ö., Turkekul, İ., Elmastaş, M., & Tuzen, M. (2004). Analysis of heavy metals in some wild-grown edible mushrooms from the middle black sea region, Turkey. *Food Chemistry,* 86, 547-552.

Kabagambe, E. K., Tsai, M. Y., Hopkins, P. N., Ordovas, J. M., Peacock, J. M., Borecki, I. B., & Arnett, D. K. (2008). Erythrocyte fatty acid composition and the metabolic syndrome: a National Heart, Lung, and Blood Institute GOLDEN Study. *Clin Chem*, 54(1), 154-62.

Kalac, P. (2009). Chemical composition and nutritional value of European species of wild growing mushrooms: A review. *Food Chemistry,* 113, 9-16.

Kavishree, J., Hemavathy, B. R., Lokesh, M. N., & Rajanathnamn Shashirekha, S. (2008). Fat and fatty acids of Indian edible mushrooms. *Food Chem.,* 106(2), 597-602.

Kim, J. H., Hubbard, N. E., Ziboh, V., & Erickson, K. L. (2005). Attenuation of breast tumor cell growth by conjugated linoleic acid via inhibition of 5-lipoxygenase activating protein. *Biochim Biophys Acta,* 6(3), 244-250.

Kivipelto, M., & Solomon, A. (2006). Cholesterol as a risk factor for Alzheimer's disease-epidemiological evidence. *Acta Neurol. Scand. Suppl.,* 185, 50-57.

Knudsen, H., & Vesterholt, J. (2008). *Fungi Nordica*. Nordsvamp, Copenhagen, Denmark.

Knudsen, H., & Vesterholt, J. (2012). *Fungi Nordica*.Nordsvamp, Copenhagen, Denmark.

Komura, D. L., Carbonero, E. R., Gracher, A. H. P., Baggioo, C. S., Feritas, C. S., Marcon, R., Santos, A. R. S., Gorin, P. A. J., & Lacomini, M. (2010). Structure of *Agaricus* spp. *fucogalactans* and their anti-falmmatory and antinociceptive properties. *Bioresource Technol.*, 101, 6192-6199.

Konuk, M., Afyon, A., & Yağız, D. (2007). Minor Element and Heavy Metal Content of Wild Growing and Edible Mushrooms from Western Black Sea Region of Turkey. *Fresenius Environmental Bulletin*, 16(11), 1359-1362.

Kula, İ. Solak, M. H., Uğurlu, M., Işıloğlu, M., & Arslan, Y. (2011). Determination of Mercury, Cadmium, Lead, Zinc, Selenium and Iron by Icp-Oes in Mushroom Samples from Around Thermal Power Plant in Mugla, Turkey. *Bulletin Environmental Contamination and Toxicology,* 87, 276-281.

Mahfouz, M., & Kummerow, F. (1989). Effect of Magnesium defficiency on Delta 6 desaturase activity and fatty acid composition rat liver microsomes. *Lipids,* 24(8), 727-32.

Manzi, P., Aguzzi, A., Pizzoferrato, L. (2001). Nutritional value of mushroom widely consumed in Italy. *Food Chemistry,* 73, 321-325.

Mleczek, M., Budka, A., Siwulski, M., Mleczek, P., Budzynska, S., Proch, J., Gasecka, M., Niedzielski, P., & Rzymski, P. (2021). A comparison of toxic and essential elements in edible wild and cultivated mushroom species, *European Food Research and Technology,* 247(5), 1-14.

Moser, M. (1983). *Keys to Agarics and Boleti*. Gustav Fischer Verlag, Stutgart.

Pardeshi, B. M., & Pardeshi, P. M. (2009). *The edible medicinal mushrooms as supportive natural nutrients: study of non-volatile mineral contents of some edible medicinal mushrooms from India; eastern remedies for modern western maladies,* Procin 5th Int. Medicinal Mushrooms Conference, Mycological Society of China, Nantong, China. 514-518.

Phillips, R. (2006). *Mushrooms*. Pan Macmillan Ltd., London..

Pompili, M., Longo, L., Dominici, G., Serafini, G., Lamis, D. A., Sarris, J., Amore, M., & Girardi, P. (2017). Pollyunsaturated fatty acids and suicide risk in mood disorders: A systematic review. *Progress in Neuro-Psychopharmacology & Biological Psychiatry,* 74, 43-56.

Şen, İ., Allı, H., Col, B., Celikkollu, M., & Balcı, A. (2012). *Trace metal contents of some wild-growing mushrooms in Bigadiç (Balıkesir), Turkey.* Turkish Journal of Botany, 36, 1-10.

Şen, İ., Allı, H., & Işıloğlu, İ. (2014). Bigadiç (Balıkesir) Yöresi Makrofungusları. *Mantar Dergisi*, 5(2), 9-16.

Sesli, E., Tuzen, M., & Soylak, M. (2008). Evaluation of trace metal content of some wild edible mushrooms from East Black Sea Region, Turkey. *Journal of Hazardous Material,* 160, 462-467.

Sesli, E., & Tüzen, M. (1999). Level of Trace Elements in The Fruiting Bodies of Macrofungi Growing in The East Black Sea Region of Turkey. *Food Chemistry,* 65, 453-460.

Shobab, L. A., Hsiung, G. Y., & Feldman, H. H. (2005). Cholesterol in Alzheimer's disease. *Labcet Neurol*. 4, 841-852.

Skeaff, C. M., Hodson, L., & McKenzie, J. E. (2006). Dietary-induced changes in fatty acid composition of human plasma, platelet, and erythrocyte lipids follow a similar time course. *J Nutr,* 136(3), 565-569.

Türkoğlu, A., Duru, M. E., Mercan, N., Kıvrak, İ., & Gezer, K. (2007). Antioxidant and antimicrobial activity of Laetiporus sulphureus (Bull.) Murrill. *Food Chemistry*, 101, 267-273.

Tüzen, M., Sesli, E., & Soylak, M. (2007). Trace elements levels of mushrooms species from East Black Sea region of Turkey. *Food Control*, 18, 806-810.

Tüzen, M., Turkekul, İ., Hasdemir, M., Mendil, D., & Sari, H. (2003). Atomic Absorption Spectrometric Determination of Trace Metal Contents of Mushroom Samples from Tokat, Turkey. *Analytical Letters,* 36(7), 1401-1410.

Uzun, Y., Gençcelep, H., Kaya, A., & Akçay, M.E. (2011). The Mineral Contents of Some Wild Edible Mushrooms. *Ekoloji,* 20(80), 6-12.

Vessby, B., Gustaffson, I., & Tengblad, S. (2002). Desaturation and elongation of fatty acids and insulin actions. *Ann N Y Acad Sci,* 967, 183-95.

Wang, D. C., Sun, C. H., Liu, L. Y., Sun, X. H., Jin, X. W., Song, W. L., Liu, X. Q., & Wan, X. L. (2012). Serum fatty acids profiles using GC-MS and multivariate statistical analysis: potential markers of Alzheimer's disease. *Neurobiology of Aging*, 33, 1057-1066.

Warensjo, E., Riserus, U., & Vessby, B. (2005). Fatty acid composition of serum lipids predicts the development of the metabolic syndrome in men. *Diabetologia,* 48(10),1999-2005.

Wasser, S. P., & Weis, A. L. (1999). Medicinal properties of substances occurring in higher basidiomycetes mushrooms: current perspective (review). *Int. J. Med. Mushrooms,* 1, 31-62.

Yamaç, M., Yıldız, D., Sarıkurkcu, C., Celikkollu, M., & Solak, M.H. (2007). Heavy Metals in Some Edible Mushrooms from the Central Anatolia, Turkey. *Food Chemistry,* 103, 263-267.

Yilmaz, F. (2003). Heavy metal levels in some macrofungi. *Turk J Bot,* 27, 45-56.

Yu, Y., Cai, Z., Zheng, J., Chen, J., Zhang, X., Huang, XF., & Li, D. (2012). Serum levels of polyunsaturated fatty acids are low in Chinese men with metabolic syndrome, whereas serum levels of saturated fatty acids, zinc and magnesium are high. *Nutrition Research*, 32, 71-77.

Zhangi M., Cui, S.W., Chueng, P.C., & Wang, K.Q. (2007). Antitumor polysaccharides from mushrooms: a review on their isolation process, structural characteristics and antitumor activity. *Trends Food Sci. Tech.,* 18, 4-19.