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Determination of Fatty Acid Contents of Five Wild Edible Mushroom Species Collected from Anatolia

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The fatty acid contents of five wild edible mushroom species (*Amanita ceciliae*, *Armillaria mellea*, *Cantharellus cibarius*, *Chlorophyllum rhacodes* and *Rhizopogon roseolus*) collected from different regions from Anatolia were determined. The fatty acids were identified and quantified by gas chromatography and studied using fruit bodies. Fatty acid composition varied among species. The dominant fatty acid in fruit bodies of all mushrooms was cis-linoleic acid (18:2). Percentage of cis-linoleic acid in species varied from 31.81 % to 57.70 %. The other major fatty acids were, respectively, cis-oleic, palmitic and stearic acids. Fatty acids analysis of the mushrooms showed that the unsaturated fatty acids were at higher concentrations than saturated fatty acids.

Key words: Anatolia, Fatty acid, Wild edible mushroom

According to Barros *et al*.[1] there are over than 2000 different species of mushrooms exist in nature, but only less than 25 species are consumed as food and having commercial value. Also, in recent years wild mushroom species are gaining importance in our diet for their nutritional and pharmacological attributes[1]. Mushrooms have high vitamin and mineral content whereas they have low fat contents and low calories[2]. On the other hand, they are rich in protein content[3]. Additionally, several mushroom species have been known to have beneficial effects on preventing illnesses such as cancer, hypercholesterolemia and hypertension [4]. As Pedneault *et al*. [3] reported linoleic and alpha linoleic acids are essential for basal metabolism and long-chained polyunsatured fatty acids have beneficial affects on consumer health.

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It is reported that, lipid contents of different species of mushrooms are among 1.75% and 15.5% on dry basis [5]. On the other hand, although the edible wild mushrooms are more expensive than cultivated mushrooms, people prefer to consume cultivated mushrooms because of their flavor and textural attributes [6]. It is necessary to determine the biochemical attributes of mushroom species, because it is known that many edible mushroom species have high levels of unsatured fatty acids [7]. Fatty acid contents of several mushrooms were studied previously [8] and it was determined that mushrooms have highly variable fatty acid profiles. Palmitic (16:0), oleic (9-cis 18:1) and linoleic (9-cis,12-cis 18:2) acids were determined as main fatty acids found in members of the Basidiomycetes [3]. Barros *et al*. [1] reported that the major fatty acids of *Agaricus arvensis*, *Lactarius deliciosus*, *Leucopaxillus giganteus*, *Sarcodon imbricatus* and *Tricholoma portentosum* were linoleic acid and oleic acid. Li *et al*. [9] revealed that 27.4% of the total fatty acids were polyunsaturated fatty acids (PUFA). Many species

of wild mushrooms are used for medicinal purposes but consumers can not consume them because of their relative scarcity. According to Zacharia and Doshi [10], to commercialize these wild mushroom species, many studies must be realized on the development of cultivation methods of these mushroom species.

In this study, fatty acid composition of five wild edible mushroom species collected from different regions of Anatolia, Turkey were analyzed to evaluate their nutritional values.

MATERIALS AND METHODS

Samples

In this study, five wild edible mushroom species (*Amanita ceciliae* (Berk. & Broome) Bas, *Armillaria mellea* (Vahl) P. Kumm., *Cantharellus cibarius* Fr., *Chlorophyllum rhacodes* (Vittad.) Vellinga, and *Rhizopogon roseolus* (Corda) Th. Fr.) were analyzed for their fatty acid compositions. Origin and habitat information of these macrofungi has given in Table 1. All of the analyzed mushrooms were identified as edible macrofungi belonging to class *Basidiomycetes*. The samples of the above five species were collected from different regions of Anatolia. All macrofungi samples were deposited in the Biology Department, Ankara University, Turkey.

Fatty acid composition

The dried mushroom samples were powdered to ~1 mm particle size and used for analysis. Fatty acids methyl esters were prepared according to the Barros *et al*.[1]. The instrumentation used for the analyses was as follows: Agilent Technologies Gas Chromatography (model 6890 N) equipped with DB-23 fused-silica capillary column (60 m × 0.25 mm i.d., 0.25 ìm film thickness; Supelco Inc., Bellefonte, PA, USA) and a flame ionization detector. The injection volume was 1.2 ìL. The column temperature was 140^{0}C, for a 5 min hold, and then programmed to increase to 220^{0}C at a rate of 4^{0}C/min and then held for 10 min. the split ratio was 1:50. Hydrogen was used as the carrier gas and its' flow rate was 1 mL/min [1]. The identification of the peaks was made by retention times and by comparing them with authentic standards analyzed under the same conditions

Statistical analysis

The data presented are the averages of the results of three replicates with a standard error of less than 5%.

RESULTS AND DISCUSSION

In the present work, fatty acid compositions of fruit bodies of five wild edible mushroom species (*Amanita ceciliae*, *Armillaria mellea*, *Cantharellus cibarius*, *Chlorophyllum rhacodes* and *Rhizopogon roseolus*) were investigated. The fatty acid compositions were different among all species. Unsaturated fatty acid levels were higher than saturated. The carbon chain lengths of fatty acids were from 4 to 24. Cis-linoleic acid was the major fatty acid detected in all species. In addition to cis-linoleic acid, cis-oleic, palmitic and stearic acids were the other abundant fatty acids in the mushrooms. These four fatty acids were present in all of the mushrooms examined. Similar observations have been made in other mushrooms [1, 2].

The fatty acid compositions of the wild edible mushrooms analyzed are shown in Table 2. All the mushrooms analyzed contained large quantities of essential fatty acid; cis-linoleic acid. Essential fatty acids are fatty acids that humans and other animals must ingest because the body requires them for good health but cannot syntesize them [11]. Cis-linoleic acid (18:2) was obtained in high amounts in *Rhizopogon roseolus* (57.70 %). Cis-

Table 1. Fungarium numbers and locality information of five wild edible mushroom species

Species	Fungarium No	Coordinates	Localities
Amanita ceciliae	Akata 3037	N 40^0 53', E 39^0 50'	Trabzon
Armillaria mellea	Akata 2936	N 40^0 35', E 31^0 16'	Bolu
Cantharellus cibarius	Akata 3011	N 40^0 53', E 39^0 50'	Trabzon
Chlorophyllum rhacodes	Akata 2005	N 41^0 09', E 33^0 50'	Ilgaz Mountain
Rhizopogon roseolus	Akata 3024	N 40^0 35', E 31^0 15'	Bolu

linoleic acid occurred in large amounts in the fruit bodies of *Cantharellus cibarius* (49.62 %) and *Armillaria mellea* (48.56 %) compared to other fatty acids. These results were in agreement with the previous reports that many mushroom species had high proportions of unsaturated fatty acids, especially linoleic acid [12,13]. It is known that, linoleic acid is the precursor of 1-octen-3-ol, known as the

Table 2. Composition of fatty acids in five wild mushrooms (dry basis, % of total fatty acid)

Fatty Acids	AC	CC	AM	RR	CR
C4:0 butyric acid	0.01	0.20	0.01	0.02	0.19
C6:0 caproic acid	0.01	0.06	0.01	0.01	0.06
C8:0 caprilic acid	0.05	0.15	5.01	0.34	0.19
C10:0 capric acid	0.11	0.49	0.15	0.18	2.00
C11:0 undecanoic acid	0.14	0.04	0.07	0.28	0.12
C12:0 lauric acid	0.03	0.09	0.62	0.14	0.22
C13:0 tridekanoic acid	0.01	0.03	0.04	0.03	0.06
C14:0 myristic acid	0.24	0.46	0.38	0.17	1.71
C14:1 myristoleic acid	0.02	0.03	0.01	0.02	0.19
C15:0 pentadecanoic acid	0.26	0.41	0.96	0.57	0.76
C15:1 pentadesenoic acid	0.03	0.38	0.02	0.06	0.06
C16:0 palmitic acid	16.42	17.05	12.59	8.53	19.08
C16:1 palmitoleic acid	0.62	0.57	3.55	0.56	5.28
C17:0 margaric acid	0.04	0.15	0.11	0.29	0.20
C17:1 heptadesenoic acid	0.02	0.08	0.03	0.18	0.17
C18:0 stearic acid	3.58	5.56	3.25	2.38	7.72
C18:1 tr-oleic acid	0.14	0.09	0.05	0.09	0.06
C18:1 cis-oleic acid	42.74	21.12	22.68	19.72	9.06
C18:2 tr-linoleic acid	0.00	0.16	0.02	0.05	ND
C18:2 cis-linoleic acid	31.81	49.62	48.56	57.70	47.77
C18:3 linolenic acid	0.01	0.02	ND	0.02	0.02
C20:0 arachidic acid	0.32	0.29	0.15	0.59	0.52
C20:1 eicosenoic acid	0.31	0.22	0.06	0.52	0.00
C20:2 eicosadienoic acid	0.19	0.14	0.00	0.35	0.32
C21:0 heneicosanoic acid	0.03	0.03	0.03	0.11	0.07
C20:3 n=3 cis-11,14, 17-eicosatrienoic acid	ND	ND	ND	ND	ND
C20:4 arachidonic acid	0.01	0.07	0.02	0.05	0.03
C20:3 n=6 cis-8,11, 14-eicosatrienoic acid	ND	0.03	ND	0.04	0.02
C22:0 behenic acid	0.06	0.25	0.07	0.29	0.08
C20:5 eicosapentaenoic acid	0.39	0.26	0.10	1.31	0.88
C22:1 erucic acid	0.21	0.37	0.10	0.63	0.27
C22:2 docosadienoic acid	1.05	0.25	0.19	0.70	0.16
C23:0 tricosanoic acid	0.05	0.00	0.03	0.05	0.05
C24:0 lignoseric acid	0.66	0.81	0.36	0.46	1.50
C24:1 nervonic acid	ND	ND	ND	ND	0.00
C22:6 docosahexaenoic acid	0.33	0.45	0.22	1.95	0.42
SFA (saturated fatty acids)	21.99	26.03	23.80	14.41	34.49
MUFA (monounsaturated fatty acids)	44.07	22.85	26.47	21.76	15.07
PUFA (polyunsaturated fatty acids)	33.95	51.22	49.18	63.73	49.75

AC: *Amanita ceciliae*; CC: *Cantharellus cibarius*; AM: *Armillaria mellea*;
RR: *Rhizopogon roseolus*; CR: Chlorophyllum *rhacodes*; ND: Not Determined

alcohol of fungi, which is the principal aromatic compound in most fungi and might contribute to mushroom flavour [12, 14]. The percentages of cis-oleic acid in the fruit bodies of *Amanita ceciliae*, *Armillaria mellea* and *Cantharellus cibarius* were 42.74, 22.68 and 21.12 %, respectively. Fortunately, trans isomers of unsaturated fatty acids were detected very low amounts (0.00 – 0.16 %) in the studied mushrooms (Table 2). A rapidly expanding literature documents the importance of trans fatty acids (TFAs) in human health due to the increased risk of cardiovascular disease where they are negatively correlated with plasma HDL-cholesterol concentration and positively correlated with plasma LDL-cholesterol level [15]. It is also important to point out that, in contrast to other fungi [16, 17], no other fatty acids with an odd number of carbon atoms have been detected in considerable amounts.

In previously studies; sixteen species of wild edible mushrooms found in Poland contained 66-82 % linoleic acid and 10-20 % palmitic acid; whereas lauric, myristic, stearic, arachidic, oleic and palmitic acids were in smaller fractions [18]. Linoleic and palmitic acids were the predominant fatty acids of both glycolipids and phospolipids in *Pleurotus florida* [19]. Saturated and monounsaturated fatty acids were 20.2 and 63.9 % in *P. ostreatus*, respectively [7]. Linoleic and palmitic acids were 63.7 and 18.6 % in *F. velutipes*, respectively [2].

CONCLUSION

Edible mushrooms can be regarded as healthy foods – poor in fat. Low calorie and low fat diets are recommended for people with high blood cholesterol. Therefore mushrooms are perfect, because of their low calories, low fat composition and high essential fatty acid levels. Most of the studies on mushroom fatty acids are limited to certain mushroom species. However, the present results indicate that economically important wild edible mushrooms contain significant amounts of valuable fatty acids. Therefore, studies should be performed on fatty acid contents of other economically important and edible mushrooms.

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