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Research Article

FATTY ACIDS COMPOSITION OF TWO WILD EDIBLE MUSHROOMS IN TURKEY AND THEIR IMPORTANCE OF HUMAN NUTRITION

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ABSTRACT

In the present work, the fatty acid composition of *Tricholoma anatolicum* HH.Doğan & Intini, an endemic species, and *Cantharellus cibarius* Fr., a famous edible mushroom, were studied by the Gas chromatography (GC) method. A total of 31 different fatty acids were searched, and 29 fatty acids in *T. anatolicum* and 28 fatty acids in *C. cibarius* were determined. Oleic acid (41.31 %) is the dominant component in *C. cibarius* whereas linoleic acid is the dominant component in *T. anatolicum*. The other major fatty acid components for both species are oleic acid (33.88%), palmitic acid (10.87%) and stearic acid (6.22%) in *T. anatolicum*, and linoleic acid (17.7%), palmitic acid (15.09%) and stearic acid (8.37%) in *C. cibarius*. The results show that *T. anatolicum* and *C. cibarius* are very rich on account of saturated fatty acids, mono unsaturated fatty acids and poly unsaturated fatty acids, and they don't also have trans fatty acids. Due to both species have beneficial fatty acids to human health, they can be recommended as a major source of food diet.

INTRODUCTION

Macrofungi species have attracted people's attention in the nature for centuries. People have continuously search for ways to benefit from macrofungi. Some of them are widely consumed in many countries and their trade values are rather high. Some specific mushrooms such as the members of *Tricholoma*, *Tuber*, *Morchella*, *Agaricus*, *Russula* genera as well as the other genera members are used for commercially and their income are getting to rise per year. Some of them have been used for medical purposes such as *Ganoderma lucidum*, *Lentinus edodes*, *Codryceps* spp., *Flammulina velutipes* etc. Their culinary and commercial value is mainly due to their organoleptic properties, such as aroma and flavour (Guedes de Pinho *et al*., 2008), vitamins and minerals, additionally containing high proportions of unsaturated fatty acids (Pedneault *et al*., 2006), and also to their riches in carbohydrates, fibres (Mattila *et al*., 2000). Due to mushrooms have high protein and low fat/energy contents, thaye are an excellent food for use in low caloric diets (Barros *et al*., 2007). Lipids display an important role in human body, acting like hormones or their precursors, helping the digestion process, and constituting a source of metabolic energy. They also work as structural and functional components of biomembranes, as constituents of myelin sheath and as thermal insulators (Burtis and Ashwood, 1996; Gibney *et al*., 2002). Fatty acids are the basic building blocks of most lipids. Polyunsaturated fatty acids from omega-6 and omega-3 families have intense biological properties in low concentrations (Guedes de Pinho *et al*., 2008) and are the biosynthetic precursors of the eicosanoids (i.e. prostaglandins). These are signalling molecules with complex control over many body systems, having effects on cardiovascular diseases, triglycerides levels, blood pressure and arthritis (Voet and Voet, 2004; Ribeiro *et al*., 2009).

Turkey is a rich country for the edible mushroom potential and is becoming an exporter of wild mushrooms. *Tricholoma anatolicum* HH Doğan & Intini is known as "katran mantarı" and *Cantharellus cibarius* Fr. is "cüce kız" by the local people in Turkey. The harvesting of those two species constitutes a way of subsistence for the local residents, playing an important role in the regional and national commerce. Moreover, *T. anatolicum* is exported to Japan as matsutake mushroom and *C. cibarius* is exported to European countries. Although there are some studies on cultivated and wild edible mushrooms, there is no information available about fatty acid composition of these two edible mushrooms of Turkey. In the present study, we intend to evaluate the fatty acid compositions of wild and commercial mushrooms.

MATERIAL AND METHODS

Collection of the species

T. anatolicum samples were collected from Karaman-Başyayla district in the Mediterranean region in 2007 and *C. cibarius* samples were collected from Ordu district in the Black Sea region in 2007. The species identification was performed as

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described in the literature (Intini *et al*., 2003; Bretienbach and Kränzlin, 1986). Stock samples of the species were also deposited at the Fungarium of the Mushroom Application and Research Centre, Selçuk University, Konya, Turkey.

Sample preparation

The fruiting bodies of each mushroom samples were dried in a dehydrator at 37–40ºC for 5 days. The dried samples were homogenised in a household blender at full speed until they turned into powder.

Fatty acid extraction

To obtain the crude oil of the mushrooms, a powdered fungus sample (30 g) was extracted with 250 ml of petroleum ether in a Soxhlet apparatus for 8 h (Anonymous, 1990). A total of 0.16–0.20 g of the oil sample was added to a round-bottom flask containing 4 ml of a 0.5 N methanolic NaOH extract, and then the mixture was boiled in a water bath for 10 min until saponification occurred. After saponification, 5 ml of 14% BF_3-methanol complex was added to the flask, and the mixture was boiled for 5 min. Next, the flask was shaken, and 2 ml n-heptane was added. All the extract mixtures were boiled for 1 min, and 4 ml NaCl (a saturated solution) was added. After the extract was thoroughly mixed, it was transferred into a separating funnel, and the phases were allowed to separate for 5–10 min. The lower aqueous phase was discarded, and the upper, light-yellow coloured phase was aliquoted into phials, which were stored in a freezer until needed.

Gas chromatography analysis

A gas chromatography analysis was performed using an HP 6890 model Hewlett Packard Agilent gas chromatograph with an automatic injector and a flame ionisation detector. A 100-metre HP-88 capillary column was used in the analysis. The temperature of the injector block was set to 240 ºC, and the detector block was set to 250 ºC. The column temperature was initially set to 160°C for 2 min, and then increased to 185°C at a rate of 4°C per min. This was followed by a temperature increase of 1°C per min to 200°C. After 200°C was reached, the column was held at this temperature for 46.75 min. The analysis was completed in 70 min. The helium flow was set to 1 ml/min. Alltech and Accu standards were used for the determination of the fatty acid content. The results were given as a per cent of the total substances. The standard errors ranged from ± 1–3%, and three GC analysis results were averaged together.

RESULTS AND DISCUSSION

Saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) of *T. anatolicum* and *C. cibarius* were analysed by the gas chromatography method (Table).

A total of 31 fatty acids were checked in both two fungal species and of them, 29 fatty acids were determined in *T. anatolicum* while 28 fatty acids were determined in *C. cibarius*. Pentadecanoic acid and lignoseric acid were not found in *T. anatolicum*, and palmitoleic acid, eicosadienoic acid and docosapentaenoic acid were not found in *C. cibarius*. These identified fatty acids varied in length from C10 to C24. The largest component of the total fatty acid pool was identified as oleic acid (43.31%) in *C. cibarius* and linoleic acid (35.86%) in *T. anatolicum*. Additionally, MUFA, measured as 47.95% of the total fatty acid composition, are more abundant than SFA (27.75%) and PUFA (24.32%) in *C. cibarius* whereas PUFA, measured as 36.44% of the total fatty acid composition, are more abundant than MUFA (36.44%) and SFA (17.98%) in *T. anatolicum*.

Table Fatty acid levels of *Tricholoma anatolicum* and *Cantharellus cibarius.*

Carbon numbers	*Tricholoma anatolicum*	*Cantharellus cibarius*	Common and Systematic Names
C 10:0	0.06 ± 0.01	0.05 ± 0.01	Capric acid
C 11:0	0.04 ± 0.02	0.03 ± 0.01	Andesilic acid
C 12:0	0.03 ± 0.01	0.11 ± 0.01	Lauric acid
C 13:0	0.02 ± 0.01	0.03 ± 0.01	Tridecanoic acid
C 13:1	0.02 ± 0.01	0.03 ± 0.01	Tridesilic acid
C 14:0	0.36 ± 0.01	0.81 ± 0.01	Myristic acid
C 15:0	0.07 ± 0.01	0.21 ± 0.02	Pentadesilic acid
C 16:0	10.87 ± 0.03	15.09 ± 0.02	Palmitic acid
C 17:0	0.13 ± 0.01	2.51 ± 0.02	Margaric acid
C 18:0	6.22 ± 0.03	8.37 ± 0.01	Stearic acid
C 20:0	0.10± 0.01	0.19 ± 0.01	Eicosanoic acid
C 21:0	0.089 ± 0.01	0.35 ± 0.01	Heneicosanoic acid
∑ SFA*	**17,98 ± 0.04**	**27,75 ± 0.03**	
C 14:1n5	0.77 ± 0.01	0.08 ± 0.01	Myristoleic acid
C 15:1n5	0	0.07 ± 0.01	Pentadecanoic acid
C 16:1n7	0.72 ± 0.02	0	Palmitoleic acid
C 17:1n8	0.42 ± 0.01	0.31 ± 0.01	Cis-10-Heptadecanoic acid
C 18:1n9	33.88 ± 0.09	41.31 ± 0.05	Oleic acid
C 20:1n9	0.50 ± 0.04	0.02 ± 0.01	11 Eicosenoic acid
C 22:1n9	0.15 ± 0.01	0.05 ± 0.01	13-Docosanoic acid
C 24:0	0	1.12 ± 0.01	Lignoseric acid (Tetracosanoic acid)
C 24:1n9	0.05 ± 0.01	4.99 ± 0.01	15-Tetracosenoic acid
∑ MUFA	**36.44 ± 0.01**	**47.95 ± 0.01**	
C 18:2n6	35.86 ± 0.01	17.7 ± 0.01	Linoleic acid
C 18:3n3	5.04 ± 0.01	0.33 ± 0.01	Linolenic acid
C 20:2n6	0.32 ± 0.01	2.11 ± 0.02	11,14- Eicosadienoic acid
C 20:3n6	0.12 ± 0.01	0	8,11,14-Eicosatrieonic acid
C 20:4n6	1.12 ± 0.02	2.60 ± 0.01	5-8-11-14 Eicosatetraeonic acid
C 20:5n3	0.56 ± 0.02	0.23 ± 0.01	5-8-11-14-17 Eicosapentaenoic acid
C 22:2n6	0.10 ± 0.02	0.65 ± 0.01	Cis-13,16-Docosadienoic acid
C 22:4n6	0.08 ± 0.01	0.37 ± 0.01	7-10-13-16 Docosatetraenoic acid
C 22:5n6	0.22 ± 0.01	0	4-7-10-13-16 Docosapentaenoic acid
C 22:6n3	1.41± 0.01	0.33 ± 0.01	4-7-10-13-16-19 Docosahexaenoic acid
∑PUFA*	**44.83±0.03**	**24,32± 0.01**	

The most abundant fatty acid found in *T. anatolicum* was linoleic acid (35.86%). This was followed by oleic acid (33.88%), palmitic acid (10.87%) and stearic acid (6.22%). These four most abundant fatty acids together composed 86.83% of the total fatty acid pool. The most abundant fatty acid found in *C. cibarius* was oleic acid (41.31%). This was followed by linoleic acid (17.77%), palmitic acid (15.09%) and stearic acid (8.37%). These four most abundant fatty acids together composed 82.54% of the total fatty acid pool.

The main fatty acid components of *Lactarius deliciosus*, *Sarcodon imbricatus* and *Tricholoma portentosum* consisted of MUFA, while PUFA were the most abundant components of *Agaricus arvensis* and *Leucopaxillus giganteus* (Barros *et al*., 2007). Unsaturated fatty acids were found at higher concentrations than saturated fatty acids in the total fatty acids of mushrooms analysed by Mauger *et al*. (Mauger *et al*., 2003).

Doğan (2016) found UFA as 61.48% for *Terfezia boudieri* and 63.59% for *Lactarius vellereus*. In the present study, the high UFA content of *T. anatolicum* (81.27%) and *C. cibarius* (72.27%) are consistent with these results.

and *Armilleria mellea* were investigated, and the amount of unsaturated fatty acids present was found to be higher than that of saturated fatty acids.

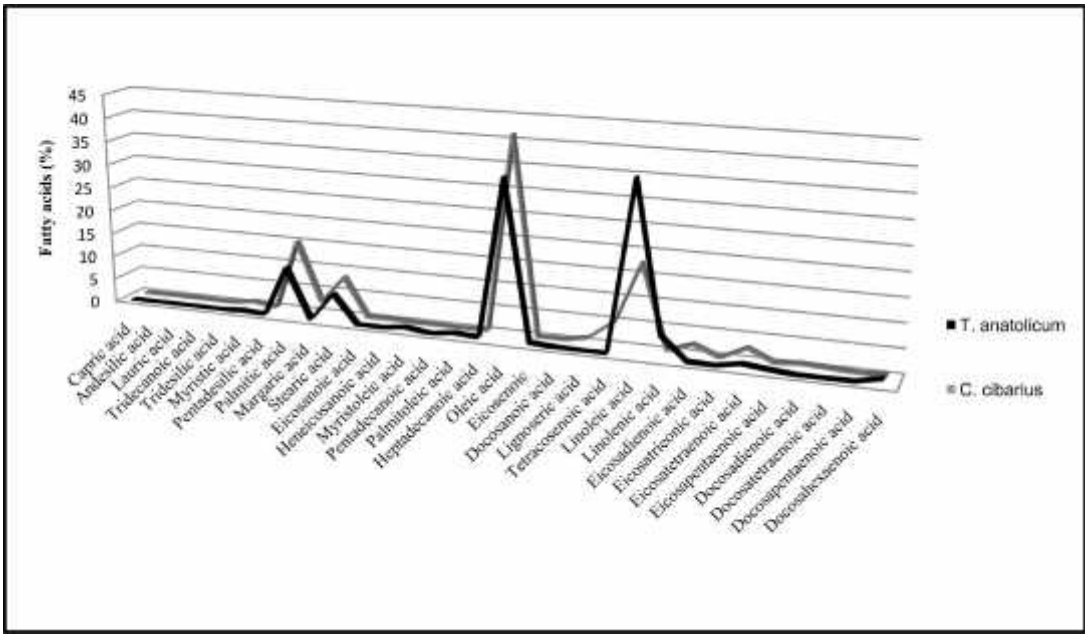

Figure % fatty acid levels of *Tricholoma anatolicum* and *Cantharellus cibarius.*

Palmitic acid is the most common saturated fatty acid in plants and animals. This is the primary fatty acid from which other longer fatty acids are synthesised. Palmitic acid cannot be found in the free form like other fatty acids in nature, and the level of palmitic acid in *Amanita caesarea* as 15% (Doğan and Akbaş 2013), 29,59% for *Terfezia boudieri* and 28,61% for *Lactarius vellereus* (Doğan 2016). In the present study palmitic acid levels were found as 10.87 and 15.09% for *T. anatolicum* and *C. cibarius*, respectively. According to our results, palmitic acid levels are relatively the same with *A. caesarea* while they are lower than *T. boudieri* and *L. vellereus*.

The most important monounsaturated fatty acid is oleic acid. Oleic acid is used in soap-making, wax production, medicine, and the textile and leather industries. Oleic acid may hinder the progression of adrenoleukodystrophy (ALD), a fatal disease that affects the brain and adrenal glands. Oleic acid may be responsible for the hypotensive (blood pressure-reducing) effects of olive oil. Adverse effects also have been documented, however, both oleic and monounsaturated fatty acid levels in the membranes of red blood cells have been associated with an increased risk of breast cancer. The oleic acid contents in *T. boudieri* and *L. vellereus* were measured as 21.64% and 21.88%, respectively (Doğan 2016).The oleic acid contents in *T. anatolicum* and *C. cibarius* were measured as 33.88% and 41.31% respectively; these rates are useful levels for dietary purposes.

In this study, trans fatty acid (TFA) isomers were not found. Increasing amounts of trans fatty acids in plasma have been linked to increasing LDL cholesterol levels, which raise the risk of cardiovascular disease and harm to human health (Minamide and Hammond, 1985). The fatty acid composition of *Agaricus bisporus, Agaricus campestris, Coprinus comatus, Boletus edulis, Pleurotus ostreatus, Oudemansiella radicata*

The carbon chain length was found to be between 8 and 24. Linoleic acid was discovered to be common to all mushroom species. In addition, palmitic acid, oleic acid, stearic acid and arachidic acid were the most abundant fatty acids identified in a study of various fungi (Yilmaz *et al*., 2006). Oleic acid and linoleic fatty acids of *T. anatolicum* and *C. cibarius* were observed to be the most abundant fatty acids. Palmitic and stearic acid were found to be the next most prevalent components of *T. anatolicum* and *C. cibarius* (Figure). Linoleic acid, an essential fatty acid, composed 35.86% of *T. anatolicum* and 17.7% of *C. cibarius* in the total fatty acids.

The total fatty acids in *T. anatolicum* and *C. cibarius* are as follows: saturated fatty acids (17.98% and 27.75%), monounsaturated fatty acids (36.44% and 47.95%) and polyunsaturated fatty acids (44.83% and 24.32%). However, in the earlier studies of fungi, unsaturated fatty acid contents ranged from 59.9% to 90.4% of the total fatty acids and were also more abundant than saturated fatty acids.

According to fatty acid analysis of *T. anatolicum* and *C. cibarius*, the total fatty acids found were small in total amount but enriched in unsaturated fatty acids.

CONCLUSIONS

Unsaturated fatty acid compositions of *T. anatolicum* and *C. cibarius* were revealed to be relatively high. Fungal species can be a source of healthy foods, contributing high levels of unsaturated fatty acids.

The present results indicate that economically important and edible mushrooms can display significant source of fatty acids. Therefore, these studies should be extended to other economically important and edible mushrooms.

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