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ABSTRACT

In the present work, the fatty acid compositions of *Terfezia boudieri* Chatin, desert truffle, and *Lactarius vellereus* (Fr.) Fr., milky mushroom, were estimated via the method of gas chromatography analysis. A total of 37 different fatty acids were searched and all fatty acids were determined in the different ranges in both species. Linoleic acid was determined to be the dominant component in *T. boudieri* (36%) and *L. vellereus* (37.43%). The other major fatty acid components for *T. boudieri* and *L. vellereus* were palmitic acid (29.59% and 28.61%), oleic acid (21.64% and 21.88%) and stearic acid (6.81% and 6.24%), respectively.
The results demonstrated that *T. boudieri* and *L. vellereus* contains saturated fatty acids, mono unsaturated fatty acids and poly unsaturated fatty acids, while they don't have trans fatty acids.

INTRODUCTION

Some wild edible mushrooms are widely consumed in many countries and their trade values are rather high. Some specific mushrooms such as *Tricholoma*, *Tuber*, *Morchella*, *Agaricus* and the other genera members are used for commercially, and their income are getting to rise per year. Their culinary and commercial value is mainly due to their organoleptic properties, such as aroma and flavour (Guedes de Pinho *et al*., 2008), and also to their riches in carbohydrates, fibres (Mattila *et al*., 2000), vitamins and minerals, additionally containing high proportions of unsaturated fatty acids (Pedneault *et al*., 2006). The high protein and low fat/energy contents of wild edible mushrooms make them an excellent food for usage 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 and blood pressure (Voet and Voet, 2004; Riberio *et al*., 2009).

Turkey is a rich country for the edible mushroom potential and is becoming an exporter of wild mushrooms. *Terfezia boudieri* Chatin is known desert truffle and *Lactarius vellereus* (Fr.) Fr. is "milky mushroom" 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. boudieri* is exported to Arabian countries and *L. vellereus* is sold in open markets. Although there are some studies on cultivated and wild edible mushrooms, nevertheless there is no information available about fatty acid composition of these two edible mushrooms of Turkey. In the present study, I intend to evaluate the fatty acid compositions of wild and commercial mushrooms.

MATERIAL AND METHODS

Collection of the species

T. boudieri samples were collected from Karaman-Kılbasan village in 2010 and *L. vellereus* samples were collected from Ordu district in the Black Sea region in 2007. The species identification was performed as described in the literature (Montecchi and Sarasini 2000; Galli, 2006). 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 37-40°C for 5 days. The dried samples were

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homogenised in a household blender at full speed until they turned into powder.

Fatty acid extraction

A powdered 30 g mushroom sample 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 0.5 N methanolic NaOH extract; subsequently, the mixture was boiled in a water bath for 10 min until saponification occurred. After that, 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. Once 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 till used.

Gas chromatography analysis

Chromatographic studies were made according to Anonymous (1990). A gas chromatography analysis was performed using an HP 6890 model Hewlett-Packard Agilent gas chromatograph (Agilent/HP, Wilmington, Delaware, USA) 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 °C, and the detector block was set to 250 °C.

The column temperature was initially set to 160 °C for 2 min, and later 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. Once 200 °C was reached, the column was then held at this temperature for 46 min. The analysis was completed in 70 min. The helium flow was set to 1 mL/min. Alltech and Accu standards were applied for identification of the fatty acid content. The results were rendered as percentage of the total substances. The standard errors ranged from ± 1 to 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. boudieri* and *L. vellereus* were analysed by the gas chromatography method (Table).

A total of 37 fatty acids were identified in both two fungal species. These identified fatty acids varied in length from C6 to C24. The dominant component of the total fatty acid pool was identified as C18:2 (linoleic acid) for both species.

Additionally, SFA measured as 38.54%, of the total fatty acid composition, are more abundant than PUFA (38.32%) and MUFA (23.17%) in *T. boudieri* whereas PUFA was measured as 40.23% of the total fatty acid composition and it was more abundant than SFA (36.42%) and MUFA (23.36%) in *L. vellereus*.

The most abundant fatty acid found in *T. boudieri* was linoleic acid (36%). This was followed by palmitic acid (29.59%), oleic acid (21.64%) and stearic acid (6.81%).

Table % Fatty acid levels of *T. boudieri* and *L. vellereus*.

Carbon numbers	*T. bouidieri*	*L. vellereus*	Common and Systematic Names
C 6:0	0,06	0,03	Caproic acid
C 8:0	0,02	0,08	Caprylic acid
C 10:0	0,04	0,17	Capric acid
C 11:0	0,04	0,06	Andesilic acid
C 12:0	0,03	0,05	Lauric acid
C 13:0	0,01	0,01	Tridesilic acid
C 14:0	0,26	0,28	Myristic acid
C 15:0	0,24	0,24	Pentadesilic acid
C 16:0	29,59	28,61	Palmitic acid
C 17:0	0,16	0,09	Margaric acid
C 18:0	6,81	6,24	Stearic acid
C 20:0	0,41	0,06	Eicosanoic acid
C 21:0	0,84	0,48	Heneicosanoic acid
C 22:0	0,04	0,01	Docosanoic acid
C 24:0	0,01	0,04	Tetracosanoic acid
∑ SFA*	**38,54**	**36,42**	
C 14:1n5	0,01	0,01	Myristoleic acid
C 15:1n5	0,02	0,01	Pentadecanoic acid
C 16:1n7	0,87	0,96	Palmitoleic acid
C 17:1n8	0,47	0,42	9-Heptadecanoic acid
C 18:1n9	21,64	21,88	Oleic acid
C 20:1n9	0,04	0,04	11-Eicosenoic acid
C 22:1n9	0,10	0,04	13-Docosanoic acid
C 24:1n9	0,02	0,01	15-Tetracosenoic acid
∑ MUFA	**23,16**	**23,36**	
C 18:2n6	36,00	37,43	Linoleic acid
C 18:3n6	0,09	0,14	6-9-12-Octadecatrienoic acid
C 18:3n3	0,07	0,16	Linolenic acid
C 20:2n6	0,08	0,01	11,14- Eicosadienoic acid
C 20:3n6	0,14	0,01	8,11,14-Eicosatrieonic acid
C 20:3n3	0,01	0,08	11,14,17-Eicosatrieonic acid
C 20:4n6	0,92	0,49	5-8-11-14-Eicosatetraeonic acid
C 20:5n3	0,44	0,79	5-8-11-14-17-Eicosapentaenoic acid
C 22:2n6	0,43	0,95	Cis-13,16-Docosadienoic acid
C 22:3n3	0,07	0,02	13-16-19-Docosatrienoic acid
C 22:4n6	0,03	0,02	7-10-13-16-Docosatetraenoic acid
C 22:5n6	0,04	0,13	4-7-10-13-16-Docosapentaenoic acid
C 22:5n3	0,02	0,02	7-10-13-16-19-Docosapentaenoic acid
C 22:6n3	0,02	0,02	4-7-10-13-16-19-Docosahexaenoic acid
∑PUFA*	**38,32**	**40,23**	

*__SFA__: saturated fatty acid, __MUFA__: Mono unsaturated fatty acid, __PUFA__: Poly unsaturated fatty acid.

These four most abundant fatty acids together composed 94% of the total fatty acid pool, whereas the most abundant fatty acid found in *L. vellereus* was linoleic acid (37.43%), this was followed by palmitic acid (28.61%), oleic acid (21.88%) and stearic acid (5.33%). These four most abundant fatty acids together composed 94.16% of the total fatty acid pool (Figure).

The main fatty acid components of *Lactarius deliciosus* (L.) Gray, *Sarcodon imbricatus* (L.) P. Karst. and *Tricholoma portentosum* (Fr.) Quél. consisted of MUFA, whereas PUFA were the most abundant components of *Agaricus arvensis* Schaeff. and *Leucopaxillus giganteus* (Sowerby) Singer (Barros *et al*., 2002). Unsaturated fatty acids (UFA) were found at higher concentrations than saturated fatty acids in the total fatty acids of mushrooms analysed by Mauger *et al*. (2003). However Doğan and Akbaş (2013) found UFA as 78.55 in *Amanita caesarea* (Scop.) Pers. In the present study, the high UFA content of *T. boudieri* (61.48%) and *L. vellereus* (63.59%) are consistent with these results.

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 a free form in nature like other fatty acids. It was found in *A. caesarea* as 15% (Doğan and Akbaş 2013), and the level of palmitic acid in *T. boudieri* and *L. vellereus* are relatively higher (29, 59% and 28, 61 respectively) than *A. caesarea*. 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.

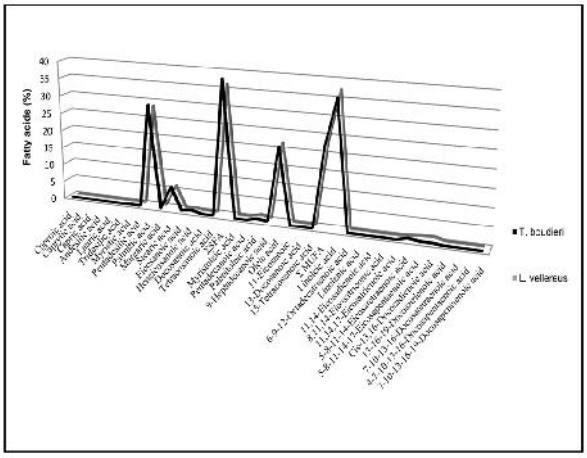

Figure. % fatty acid levels of *T. boudieri* and *L. vellereus.*

The oleic acid contents in *T. boudieri* and *L. vellereus* were measured as 21.64% and 21.88% 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* (J.E. Lange) Imbach, *Agaricus campestris* L., *Coprinus comatus* (O.F. Müll.) Pers., *Boletus edulis* Bull., *Pleurotus ostreatus* (Jacq.) P. Kumm., *Oudemansiella radicata* (Relhan) Singer and *Armillaria mellea* (Vahl) P. Kumm. were investigated, and the amount of unsaturated fatty acids present was found to be higher than that of saturated fatty acids. 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. boudieri* and *L. vellereus* were also observed to be the most abundant fatty acids.

Palmitic and stearic acid were found to be the next most prevalent components of *T. boudieri* and *L. vellereus*. Linoleic acid, an essential fatty acid, composed 36% of *T. boudieri* and 47.43% of *L. vellereus* in the total fatty acids.

The total fatty acids in *T. boudieri* and *L. vellereus* are as follows: saturated fatty acids (38% and 42%), monounsaturated fatty acids (23.16% and 23.36%) and polyunsaturated fatty acids (38.32% and 40.23%). However, in the earlier studies of mushrooms, 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. boudieri* and *L. vellereus*, the total fatty acids found were small in total amount but enriched in unsaturated fatty acids.

CONCLUSIONS

Unsaturated fatty acid compositions of *T. boudieri* and *L. vellereus* 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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