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Detection of Volatile Aroma Compounds of *Morchella* by Headspace Gas Chromatography Mass Spectrometry (HS-GC/MS)

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Abstract

This study was conducted at the Horticulture Department of Çukurova University, Adana, Turkey, in 2010 to determine the volatile aroma compounds of *Morchella* mushroom. Fresh samples of *Morchella esculenta* (Sample 1) and *Morchella elata* (Sample 2) were collected from Çanakkale (Sample 1) and Mersin (Sample 2) provinces in Turkey in the spring of 2010. Volatile aroma compounds were analyzed by headspace gas chromatography mass spectrometry (HS-GC/MS). A total of 31 aroma compounds were identified in the 2 analyzed samples: 7 alcohols, 7 esters, 7 ketones, 3 acids, 2 aldehydes, 1 terpene, phenol, 1-propanamine, geranyl linalool, and quinoline. Seventeen aroma components were identified in Sample 1, and 18 compounds were found in Sample 2. Phenol was determined as the major aroma compound in both Sample 1 and Sample 2, at 50.888% and 58.293% content, respectively. Alcohols, especially 1-octen-3-ol, were detected as the second major aroma components in Sample 1 and Sample 2, at 15.500% and 5.660% content, respectively. Carbamic acid, methyl ester was found only in Sample 1, at 11.379% content. The aroma components detected in the two samples differed. 1-Octadecanol; cyclooctylalcohol; trans-2-undecen-1-ol; butanoic acid, butyl ester (CAS); carbamic acid, methyl ester; 2-ethylhexyl-2-ethylhexanoate; phthalic acid, decyl isobutyl ester; 2,2,4-trimethyl-1,3-pentanediol diisobutyrate; decanal; nonanal; 7,9-di-tert-butyl-1-oxaspiro(4.5)deca-6,9-diene-2,8-dione; 2,5-cyclohexadiene-1,4-dione; 2,6-bis(1,1-dimethylethyl); and trans-alpha-bisabolene were detected only in Sample 1. Ethanol; silanediol, 2-methylaminoethanol; L-alanine, ethyl ester; carbonic acid, dodecyl isobutyl ester; acetic acid; butanoic acid; 2,3,4H-pyran-4-one; 5,9-undecadien-2-one; cyclooctene; 2-cyclopenten-1-one; 1-propanamine; geranyl linalool; and quinoline were determined only in Sample 2.

Keywords: alcohol, carbamic acid, Morel, phenol, 1-Octen-3-ol

Introduction

Morels (*Morchella* spp.) are among the most valuable and important mushrooms because of their taste and commercial value. These mushrooms generally appear in pine forests (*Pinus brutia*, *Pinus nigra*) in Turkey from March to June. They are picked in regions in which they are well known and transported to European countries dried or fresh. Morels provide significant income to the people living near the forests, who could sell them fresh to the companies that export the mushrooms, for approximately 30 $/kg in the beginning of the morel season. After India and Pakistan, Turkey is one of the most important morel exporter countries. It is geographically close to European Union countries, a location which, according to other exporter countries, gives Turkey an important advantage in shipping fresh morel to European destinations (Pilz *et al*., 2007). People prefer to eat this mushroom not only for its nutritional value but also for its good taste (Pilz *et al*., 2007) Iqbal (1993) reported that *Morchella* is low in calories, rich in minerals, and contains 42% protein in dry samples. Yıldız *et al*. (2004) determined the crude protein of *Morchella conica* and *M. esculenta* as 22.6 and 26.8 (calculated as N × 6.25), respectively. Gençcelep *et al*. (2009) determined the mineral contents of *Morchella* as 1.92 mg/g magnesium, 0.87 mg/g calcium, 20.4 mg/g potassium, 0.08 mg/g sodium, 2.92 mg/g phosphorus, 203 mg/g iron, 133 mg/g zinc, 73.4 mg/g copper, and 16.9 mg/g manganese in *M. vulgaris*; and 1.82 mg/g magnesium, 0.85 mg/g calcium, 23.5 mg/g potassium, 0.18 mg/g sodium, 3.49 mg/g phosphorus, 195 mg/g iron, 98.9 mg/g zinc, 62.6 mg/g copper, 54.7 mg/g manganese in *M. esculenta*.

Quality is a very important aspect of edible mushrooms and is dependent on many factors, such as colour, texture, and aroma. Mushrooms contain a lot of aroma components, including odour and taste, that are responsible for determining their chemical components. The aroma compounds of mushrooms can be detected with different techniques. However, in new researches, gas chromatography mass spectrometry (GC/MS) is the most common technique used to determine volatile aroma compounds. Many researchers have identified the aroma compounds in different mushrooms using GC/MS: MacLeod and Panchasara (1983) in *Agaricus bisporus*; Breheret *et al*. (1997) in 82 wild mushroom species; Cho *et al*. (2007, 2008) in *Tricholoma matsutake*; Pinho *et al*. (2008) in eleven edible mushrooms; Li-Juan and Gung-zhu (2010) in *Tricholoma matsutake* Sing.; and Leffingwell and Alfrod (2011) in *Calvatia*.

Morchella is one of the most common mushrooms in Turkey, being found in almost every region of the country. Several morphological (Solak *et al*., 2007) and molecular (Taşkın *et al*., 2010, 2012) studies have been done to identify the species in Turkey. However, there is no detailed study on the aroma components of this mushroom. Thus, the purpose of this research was to determine the aroma components of *Morchella* by headspace (HS)-GC/MS.

Materials and methods

Fresh morel samples collected from two different provinces in Turkey were used as materials in this study. The samples were collected from Çanakkale (Sample 1: *Morchella esculenta*) and Mersin (Sample 2: *Morchella elata*) provinces in the spring of 2010. Volatile compounds were analyzed on an HS-GC/MS apparatus equipped with an HP-5 MS (30 m × 0.25 mm × 0.25 μm) fused-silica capillary column. Helium (1 ml/min) was used as

Tab. 1. Volatile Composition of *Morchella* by Headspace Gas Chromatography Mass Spectrometry (HS-GC/MS)

R.T.	Compound name	Area %-S1	Area %-S2
Alcohol			
2.200	Ethanol	ND	5.310
7.275	1-Octen-3-ol	15.500	5.660
30.634	1-Octadecanol	0.368	ND
9.680	Cyclooctylalcohol	1.398	ND
3.49	Silanediol	ND	1.417
2.15	2-Methylaminoethanol	ND	0.157
9.674	Trans-2-Undecen-1-ol	0.812	ND
Ester			
18.489	Butanoic acid, butyl ester (CAS)	0.576	ND
2.212	Carbamic acid, methyl ester	11.379	ND
1.94	L-Alanine, ethyl ester	ND	3.044
24.410	2-Ethylhexyl-2-ethylhexanoate	0.822	ND
30.477	Phthalic acid, decyl isobutyl ester	1.654	ND
16.622	2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	0.321	ND
18.77	Carbonic acid, dodecyl isobutyl ester	ND	1.382
Acid			
24.284	Propanoic acid	3.459	0.918
3.12	Acetic acid	ND	3.937
2.18	Butanoic acid	ND	0.069
Aldehyde			
13.674	Decanal	0.378	ND
10.731	Nonanal	1.275	ND
Ketone			
31.534	7,9-Di-tert-butyl-1-oxaspiro(4.5)deca-6,9-diene-2,8-dione	0.264	ND
21.021	2,5-Cyclohexadiene-1,4-dione,2,6-bis(1,1-dimethylethyl)	0.359	ND
21.335	2,6-Di-T-butyl-4-methylene-2,5-cyclohexadiene-1-one	0.236	0.594
12.02	2,3,4H-pyran-4-one	ND	2.755
20.57	5,9-Undecadien-2-one	ND	0.349
7.30	Cyclooctene	ND	1.303
6.57	2-Cyclopenten-1-one	ND	1.049
Terpene			
21.915	Trans-alpha-bisabolene	0.850	ND
Phenol			
22.223	phenol, 2,6-bis(1,1-dimethylethyl)-4-methyl	50.888	58.293
2.11	1-Propanamine	ND	3.980
23.68	Geranyl linalool	ND	0.498
21.49	Quinoline	ND	0.524
	Other compounds	9.461	9.761

RT: Retention time;
ND: Not detected

carrier gas. The SPME holder, for manual sampling, and the fibres used in this study were purchased from Supelco (Bellefonte, PA). Polydimethylsiloxane (PDMS) fibres of 100-mm diameter were used; these were conditioned for 1 h at 240°C in the GC injector port before use and cleaned between analysis to prevent contamination. The injector temperature was 250°C, set for splitless injection. The oven conditions were set to 50°C for 1 min, after which the temperature was increased to 200°C at a rate of 4°C/min. Thermal desorption was allowed for 1.5 min. The detector temperature was 280°C. The components were identified by comparison of mass spectra and retention time data complemented with Wiley, flavour, and NIST GC/MS libraries.

Results and discussion

A total of 31 aroma compounds were identified in the 2 analyzed samples. Tab. 1 shows the obtained results. Alcohols, such as ethanol, 1-octen-3-ol, 1-octadecanol, cyclooctylalcohol, silanediol, 2-methylaminoethanol, and trans-2-undecen-1-ol were detected. Among these determined alcohols, only 1-octen-3-ol was identified in both samples. 1-Octadecanol, cyclooctylalcohol, and trans-2-undecen-1-ol were detected only in Sample 1, whereas ethanol, silanediol, and 2-methylaminoethanol were determined only in Sample 2. 1-Octen-3-ol is one of the most important mushroom alcohols, and the highest content of 15.500% was obtained from Sample 1. 1-Octen-3-ol (mushroom, butter, resinous), 3-octanol (fruity, cod liver oil, citrus, weakly nutty, fungal), 1-octanol (fruity-flowery, sweet soap, orange, waxy, sweet), 1-octen-3-one (boiled mushrooms, metallic, fungal, wild mushroom), 3-octanone (fruity, sweet, musty, floral, lavender, sweet ester), 2-octen-3-ol, and 3-octanal are the well-known and common aroma compounds (Jong and Birmingham, 1993; Taylor and Linforth, 2010).

Three different acid compounds were identified. Butanoic acid and acetic acid were determined in Sample 2. Propanoic acid was found in both Sample 1 and Sample 2. Decanal and nonanal were determined as aldehydes, and both were observed in Sample 1. Trans-alpha-bisabolene was found in Sample 1 as terpene. The phenol content was very high in both samples (Sample 1: 50.888% and Sample 2: 58.293%). 1-Propanamine, geranyl linalool, and quinoline were observed only in Sample 2. Seven esters were identified. The compounds 2,2,4-trimethyl-1,3-pentanediol diisobutyrate; butanoic acid, butyl ester (CAS); carbamic acid, methyl ester; 2-ethylhexyl-2-ethylhexanoate; and phthalic acid, decyl isobutyl ester were detected in Sample 1, whereas L-alanine, ethyl ester and carbonic acid, dodecyl isobutyl ester were observed in Sample 2.

Phenol was determined as the major aroma compound. Lee *et al*. (2010) and Tsai *et al*. (2009) reported on the antioxidant effects of phenolic compounds in mushrooms. Alcohols, especially 1-octen-3-ol, were detected as the second major aroma components in Sample 1 and Sample 2, at 15.500% and 5.660% content, respectively. Esters are used in the cosmetics industry because of their intrinsic odour. Ketones, such as acetone, steroids, and some sugars, are commonly used in industrial, medical, and chemical applications. Sample 2 was found to be very rich in terms of ketones, with 6.05% content.

Conclusions

Morels (*Morchella* spp.) are among the most valuable and important mushrooms consumed all over the world, especially in Europe, because of their aroma. The commercial value of this mushroom species is increasing year by year due to increasing demand. *Morchella* is low in calories, rich in minerals, and has 42% protein content in dry samples. People prefer to eat this mushroom not only for its nutritional value but also for its good taste. In this study, the volatile aroma compounds of *Morchella* were determined. A total of 31 aroma components were identified (alcohols, terpenes, acids, aldehydes, ketones, and esters). Phenol was the major aroma compound in Sample 1 and Sample 2, at 50.888% and 58.293%, content, respectively. Alcohols were the second major compounds, especially 1-octen-3-ol, at 15.500% content in Sample 1. Carbamic acid, methyl ester was found to be an important aroma compound, with 11.379% content in Sample 1. Whereas 17 volatile aroma compounds were identified in Sample 1 (*Morchella esculenta*), 18 components were detected in Sample 2 (*Morchella elata*). However, the aroma components detected in the two samples differed. For example, the 1-octen-3-ol content was found to be higher in Sample 1 than in Sample 2. This component is one of the most important and common mushroom aroma compounds. Carbamic acid, methyl ester was determined only in Sample 1. Some components, such as L-alanine, ethyl ester; 1-propanamine; ethanol; and acetic acid, were determined only in Sample 2.

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