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RESEARCH NOTE

Composition of the pecan truffle (*Tuber texense*)

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The proximate composition of the ascomata of *Tuber texense* Heimsch, a truffle collected from the soil beneath pecan trees in Southwestern Georgia, USA, was determined. The moisture content was 72·5%. Dry material consisted of 16·1% protein (N × 4·38), 2·8% lipid, 75% carbohydrate (by difference) and 6·1% ash. Protein was deficient in methionine, but contained a higher percentage of cystine compared to fruiting bodies of several edible fleshy fungi. Oleic (45·9%), linoleic (38·0%) and palmitic (11·4%) acids constituted the major fatty acids of *T. texense* lipid. Potassium (2·49%), phosphorus (1·29%) and sulfur (0·68%) were the major elements detected in dried ascomata.

INTRODUCTION

The Pèrigord truffle (*Tuber melanosporum*) has been described as the most delicious of the edible fleshy fungi. While several species of truffles can grow in soil in association with oak, hazel, chestnut, lime, yoke elm, poplar and pine trees under French ecological conditions (Delmas, 1978), growers of *T. melanosporum* use only one of seven species of oak (*Quercus*). Consumption of truffles dates far back into antiquity but it is to Theophrastus (372–287 BC) that the original authorship on the truffle is given, which he considered as a plant without roots produced by the heavy rains of autumn (Delmas, 1978).

The hypogeous ascomycetes or Tuberales in North America have been studied only within the last century. Collections have been made at locations as far north as Alaska and several Canadian provinces (Gilkey, 1954). Heimsch (1958) described the first recorded truffle from Texas. He discovered ascomata of the fungus while cultivating the soil in a planting bed at the base of a pecan [*Carya illinoensis* (Wang.) K. Koch] tree in Austin, and named it *Tuber texense* Heimsch, a previously undescribed species of *Tuber*. The same species has been more recently detected in pecan groves in Southwestern Georgia (Hanlin *et al.*, 1989). The study reported here was undertaken to determine the proximate composition of *T. texense* ascomata.

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MATERIALS AND METHODS

Truffles were collected from the soil beneath the canopy of pecan trees in Dougherty County, Georgia, on 31 July, 1991, sealed in polyethylene bags and placed on crushed ice for transport to the laboratory. The ascomata were sliced in pieces ca. 2 mm-thick and frozen at −17°C. Samples (100 g) were freeze-dried (Virtis, model 10-109T-D, Gardener, NY) and then placed in a desiccator under vacuum at 1°C. The moisture content was calculated by measuring the difference in weight of samples before and after drying.

Dried ascomata were ground in a Retsch Microjet grinder (F. Kurt, Retsch GmbH, type ZM1, Germany) using a 0·2 mm screen. The ash content of the powder was determined by subjecting 10-gram samples to 250°C for 2 h followed by treatment at 550°C for 16 h in a muffle furnace; the residue was weighed and the percentage ash was calculated. Mineral content was

determined using an Arc-Spark Emission Spectrograph (Thermo Garrell-Ash, Model 750, Franklin, MA). Sulfur content was determined by using a Leco Sulfur Analyzer (Leco, Model 132, St. Joseph, MI).

Powdered samples were analyzed for total petroleum ether-extractable compounds by the Soxhlet method using a Goldfisch fat extractor (Labconco Corp., Kansas City, MO), i.e. total crude lipid content. Fatty acid methyl esters were prepared according to the procedure of Morrison & Smith (1964) and quantitated using gas liquid chromatography. A glass capillary column (J & W DB-225; 30m × 0·25 mm; 0·15 μm film) attached to a Hewlett-Packard 5790A Series gas chromatograph was used for separating esterified fatty acids. The oven was programmed for 10 min at 180°C followed by heating to 220°C at a rate of 4°C/min and then held at 220°C for an additional 20 min. The injector and detector temperatures were both 250°C. The helium flow rate was 0·16 ml/min with a split ratio of 280:1. Relative retention times of fatty acid methyl ester standards (Supelco Inc., Belfonte, PA) subjected to the same condition as the samples were used to identify chromatographic peaks while peak area was integrated with a Hewlett-Packard 3390A integrator.

Nitrogen content was determined by the Kjeldahl procedure (AOAC, 1980). Amino acid analysis was done using the procedure described by Haydon & Hobbs (1991), except that cystine and tryptophan were not analyzed separately. A conversion factor of 4·38 was used to convert percentage nitrogen to percentage crude protein.

Fig. 1. Whole (top) and sliced (bottom) ascocarps of *Tuber texense*.

RESULTS AND DISCUSSION

Shown in Fig. 1 are whole and sliced pecan truffles. The size, shape, color and general appearance of the ascomata and their internal features were as described by Hanlin *et al.* (1989).

The moisture content of *T. texense* ascomata is 72·5%, considerably lower than the 88–91% range that normally characterizes fruiting bodies of basidiomycetes such as *Agaricus bisporus, Flammulina velutipes, Lentinus edodes* and *Pleurotus ostreatus* (Food and Agriculture Organization, 1972). The moisture content of *T. melanosporum* is reported to be 77·1% (Singer, 1961).

It was assumed that approximately 70% of the nitrogen in *T. texense* ascomata is protein nitrogen and thus a factor of 4·38 was used to convert percent nitrogen (3·67%) to percent crude protein (16·1%, dry weight basis). This value is less than the 23·3% reported by Singer (1961) but similar to the 16·8–18·2% range reported by Delmas (1978) for *T. melanosporum*. Crisan & Sands (1978) summarized data on *A. bisporus* which revealed that the crude protein content (dry weight basis) ranges from 24–44% Aside from actual differences in protein content of fruiting bodies of various genera and species of edible fleshy fungi, growth conditions, age and the analytical method chosen for quantitating nitrogen can also result in marked differences in values (Weaver *et al.*, 1977).

The amino acid composition of *T. texense* is listed in Table 1. For the purpose of comparison, the amino acid composition of fruiting bodies of five other fleshy fungi is also listed. Like most non-animal proteins, the proteins of these fungi are deficient in methionine. The ascomata of the *Tuber* spp., however, appear to contain proteins with higher proportions of cystine compared to that reported for fruiting bodies of *Morchella deliciosa, A. bisporus, L. edodes* and *P. ostreatus*. The percentage of total amino acids which are essential for human metabolism is similar in proteins of the six fungi listed in Table 1.

Listed in Table 2 are the percentages of fatty acids in the lipid fraction of *T. texense*. The fatty acid profile of *A. bisporus* (Mau *et al.*, 1991) is also listed for the purpose of comparison. The lipid content (dry weight basis) of *T. texense* is 2·83%, compared to 3·54% for *A. bisporus*. The oleic acid content of *T. texense* lipid is much higher (45·9%) than that of *A. bisporus* lipid (1·8%). *Tuber texense* lipid contains about half the percentage of linoleic acid reported to be present in *A. bisporus* lipid, i.e. 38·0% compared to 78·1% respectively. The higher degree of saturation of fatty acids in *T. texense* may adversely affect their nutritional value. Realistically, however, the implications to human health that might

Table 1. Comparison of amino acid composition[a] of *Tuber texense, T. brumale, Morchella deliciosa, Agaricus bisporus, Lentinus edodes* and *Pleurotus ostreatus* (grey type)

Amino Acid	*T. texense*	*T. brumale*[b]	*M. deliciosa*[c]	*A. bisporus*[d]	*L. edodes*[e]	*P. ostreatus*[f]
Isoleucine[g]	5·1	2·8	5·3	4·1	4·4	4·6
Leucine[g]	5·4	7·1	7·2	6·8	7·1	10·6
Lysine[g]	7·4	8·6	7·2	8·3	3·5	5·0
Methionine[g]	1·2	0	1·8	0·8	1·8	1·7
Cystine	1·5	2·5	1·2	0·8	0	0·5
Phenylalanine[g]	4·8	3·4	6·0	3·8	5·3	4·1
Tyrosine[g]	4·8	3·3	4·9	3·6	3·5	3·3
Threonine[g]	5·0	6·7	5·9	5·0	5·4	5·0
Tyrptophan[g]	0	0·3	0	1·9	0	1·5
Valine[g]	4·6	4·3	4·9	2·3	5·3	5·7
Arginine	4·2	11·4	6·4	10·9	7·1	5·8
Histidine[g]	2·0	4·0	0	2·5	1·8	1·9
Alanine	5·8	6·5	4·4	8·7	6·2	7·0
Aspartic acid	11·8	7·8	10·3	8·3	8·0	9·9
Glutamic acid	11·0	12·2	19·8	13·0	27·4	18·1
Glycine	16·8	6·8	4·6	4·7	4·4	4·9
Proline	4·0	6·7	4·3	9·5	4·4	5·0
Serine	4·6	5·6	5·8	5·0	4·4	5·4
Percent of total amino acids that are essential	40·2	40·5	43·2	39·9	38·1	41·9

[a] Values are presented as gram of amino acid per 100 g of corrected crude protein.
[b] Seelkopf & Schuster (1957).
[c] McKellar & Kohrman (1975).
[d] Food and Agriculture Organization (1972).
[e] Kalberer & Kunsch (1974).
[f] Sugimori *et al.* (1974).
[g] Essential amino acids

be attributed to fatty acid as well as amino acid profiles of fleshy fungi, should, in general, be considered insignificant, since the amounts of lipid and protein present in fresh, edible portions are quite small.

The ash content (dry weight basis) of *T. texense* is 6·1%, somewhat lower than the 8·3% present in *T. melanosporum* ascomata (Singer, 1961). The mineral content (dry weight basis) of *T. texense* is: aluminium (184 ppm), boron (14 ppm), calcium (700 ppm), copper (45 ppm), iron (187 ppm), magnesium (1000 ppm), manganese (14 ppm), sulfur (6800 ppm) and zinc (252 ppm). Ascomata contained 1·29% phosphorus, 2·49% potassium and 3·67% nitrogen. Delmas (1978) reported that *T. melanosporum* contained 0·24–0·52% calcium, 0·04–0·12% magnesium, 0·015% iron, 0·8–1·4% phosphorus and 2·2–3·7% potassium.

Table 2. Fatty acid composition of fruiting bodies of *Tuber texense* and *Agaricus bisporus*

Fatty Acid		Content (% of lipid)	
		T. texense	*A. bisporus*[a]
Myristic	C14:0	<0·2	0·4
Palmitic	C16:0	11·4	12·4
	C17:0	<0·2	0·6
Stearic	C18:0	3·4	3·6
Oleic	C18:1	45·9	1·8
Linoleic	C18:2	38·0	78·1
Arachidic	C20:0	<0·2	3·2
Gadoleic	C20:1	0·2	—[b]
Other		1·1	—

[a] Means of data from mushrooms grown under six types of nutrient supplementation at spawning or at casing (Mau *et al.*, 1991).
[b] None reported.

The data reported in this paper indicate that there are differences in proximate composition of ascomata of *T. texense* compared to fruiting bodies of *T. melanosporum* and other edible fleshy fungi. These differences are in many instances minor and may be influenced by cultural conditions. Beelman & Edwards (1989), in summarizing the composition and nutritional value of *A. bisporus*, concluded that considerable differences can be attributed to variations in spawn strains as well as cultural practices. The influence of soil nutrients, climatic conditions and age on proximate composition of *T. texense* deserves further investigation. The sensory quality of pecan truffles also needs to be evaluated.

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