Food Chemistry 113 (2009) 386–393

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Comparison of free amino acid, carbohydrates concentrations in Korean edible and medicinal mushrooms

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ARTICLE INFO

Article history:
Received 10 May 2007
Received in revised form 7 July 2008
Accepted 19 July 2008

Keywords:
Agaricus bisporus
Sparassis crispa
Edible and medicinal mushrooms
Disaccharides
Free amino acids

ABSTRACT

Ten popular species of both edible and medicinal Korean mushrooms were analysed for their free amino acids and disaccharides. The average total free amino acid concentration was 120.79 mg g^{-1} in edible mushrooms and 61.47 mg g^{-1} in medicinal mushrooms, respectively. The average total of free amino acids for all mushrooms, edible mushrooms and medicinal mushrooms was 91.13 mg g^{-1}. *Agaricus blazei* (227.00 mg g^{-1}) showed the highest concentration of total free amino acids; on the other hand, *Inonotus obliquus* (2.00 mg g^{-1}) showed the lowest concentration among the 10 species of mushrooms. The average total carbohydrates concentration was 46.67 mg g^{-1} in the 10 species of mushrooms, where the edible mushrooms contained 66.68 mg g^{-1} and the medicinal mushrooms contained 26.65 mg g^{-1}. The carbohydrates constituents of the 10 mushroom species were mainly mannose (36.23%), glucose (34.70%), and xylose (16.83%).

1. Introduction

Pleurotus ostreatus, *Agaricus bisporus*, *Flammulina velutipes*, *Pleurotus eryngii*, and *Lentinus edodes* are five species of popular commercial edible mushrooms in Korea. *Pleurotus ostreatus* and *A. bisporus*, oyster mushroom and button mushroom, are popular throughout the world and have been the subject of many studies. *F. velutipes* is cultivated at lower temperatures than other mushrooms; therefore, it is called the winter mushroom, and it is notable for its abnormal features of small caps and long stripes (Stamets, 2000). *P. eryngii*, king oyster mushroom, has become increasingly popular, and unlike other oyster mushrooms, the stems of which can be overly woody or chewy, this variety is pleasantly chewy from top to bottom and has the advantage of remaining firm textured in cooking, rather than melting away as many mushrooms do. *L. edodes*, shiitake mushroom, has been reported in recent research as good for preventing high blood pressure, controlling cholesterol level which helps prevent heart disease, building resistance against viruses, and fighting diseases (Çağlarımak, 2007).

Other mushrooms, *Agaricus blazei*, *Sparassis crispa*, *Brown rice – Phellinus linteus*, *Ganoderma lucidum*, and *Inonotus obliquus*, are usually used in Korea because of their medicinal properties. These mushrooms are in the spotlight because of their important immunological effects, such as maintaining health, and preventing and curing diseases, as well as helping in recovering from illnesses (Higaki, Eguchi, & Watanabe, 1997). In particular, the fruiting bodies of *S. crispa* have been reported to exhibit an excellent effect for curing human diseases such as gastric ulcer, oesophageal cancer, hypertension, and diabetes (Mao & Jigng, 1993).

The typical flavour of mushrooms is due to both volatile compounds (Maga, 1981) and nonvolatile compounds (Litchfield, 1967). The nonvolatile compounds, such as free amino acids and soluble sugars (Hammond, 1978; Hammond & Nichols, 1975; Mau, Lin, & Chen, 2001; Mau, Lin, Chen, Wu, & Peng, 1998; Mau, Lin, Ma, & Song, 2003; Yang, Lin, & Mau, 2001), are responsible for the taste of stored mushrooms (Mau, Beelman, Ziegler, & Royse, 1991).

The monomeric building blocks of the important biopolymers called proteins are the α-amino acids. Amino acids, as indicated by the name, contain an amino group ($-NH_2$) and a carboxylic acid group (–COOH), occur naturally in plant and animal tissues, and form the basic constituents of proteins (David, Wade, & Toby, 2003). Usually, the amino acid is classified nutritionally; in other words, amino acids are grouped into two classes – essential and nonessential – that is distinguished between those that the body can manufacture and those that have to come from the diet. The essential amino acids cannot be synthesised by the body and

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doi:10.1016/j.foodchem.2008.07.045

therefore need to be supplied through the diet. They are required for proper growth and maintenance of the individual. The 10 amino acids listed below are essential for humans: arginine, valine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, and tryptophan. Of the 10 listed above, two amino acids, namely arginine and histidine, can be partly synthesised by adult humans and hence are considered as semi-essential amino acids. In contrast, nonessential amino acids are those that the body can manufacture from an available source of nitrogen and a carbon skeleton. These include alanine, asparagine, aspartic acid, carnitine, citrulline, cysteine, cystine, γ-aminobutyric acid, glutamic acid, glutamine, glutathione, glycine, hydroxyproline, ornithine, proline, serine, taurine, and tyrosine.

Carbohydrates are broadly classified into three groups: monosaccharides such as ribose, arabinose, xylose, fructose, mannose, galactose, and glucose; oligosaccharides such as sucrose and trehalose; and polysaccharides. Carbohydrates are present in fungi mainly as polysaccharides (Blumenthal, 1976), and mono- and disaccharides are usually present at low concentrations in fungi, with the exception of certain storage carbohydrates (Wim, Wannet, Hermans, & Op den Camp, 2000). Saccharides have attracted much attention in recent years because of their diverse biological activities. For instance, trehalose has important functions within fungi, functioning in translocation of carbon from mycelium to fruit bodies at the onset of fructification (Hammond & Nichols, 1979; Wannet et al., 1999). Other carbohydrates might be significantly conducive to fungal metabolism. However, the determination of other carbohydrate types in fungi has received hardly any attention, because of the laborious and time-consuming analysis techniques.

The aim of the present study was to determine the concentrations of free amino acids and carbohydrates in edible and medicinal mushrooms commonly cultivated in Korea.

2. Materials and methods

2.1. Sample collection and preparation

Fresh fruiting bodies of edible mushrooms, *P. ostreatus* (Strain No. KKU-01, Chunchoo No. 2), *A. bisporus* (Strain No. KKU-02,

Table 1
Concentrations (mg g^{-1}) of free amino acids in edible mushrooms

Varieties	*Pleurotus ostreatus*	*Agaricus bisporus*	*Flammulina velutipes*	*Lentinus edodes*	*Pleurotus eryngii*	Mean	$LSD_{0.05}$
P-Ser[a]	1.33 ± 0.03[b,c]	0.84 ± 0.03	1.31 ± 0.01	1.18 ± 0.02	1.24 ± 0.05	1.18	0.07
Tau	1.01 ± 0.03	0.89 ± 0.04	1.74 ± 0.00	0.73 ± 0.01	1.05 ± 0.01	1.08	0.06
PEA	0.67 ± 0.00	0.13 ± 0.02	nd	8.17 ± 0.24	0.17 ± 0.04	1.83	0.28
Urea	12.87 ± 0.16	16.32 ± 0.13	nd	nd	5.61 ± 1.35	6.96	1.58
Asp	6.45 ± 0.15	16.13 ± 0.03	2.81 ± 0.13	2.00 ± 0.05	4.69 ± 0.25	6.42	0.38
Thr[e]	7.14 ± 0.28	7.61 ± 0.01	6.41 ± 0.15	2.31 ± 0.05	3.64 ± 0.19	5.42	0.44
Ser	8.99 ± 0.27	11.11 ± 0.05	6.83 ± 0.36	1.63 ± 0.02	4.05 ± 0.19	6.52	0.55
Glu	36.85 ± 1.37	17.96 ± 0.26	31.54 ± 0.72	15.68 ± 0.21	3.94 ± 0.17	21.19	1.83
Sar	0.18 ± 0.13	nd	nd	0.21 ± 0.15	0.15 ± 0.02	0.11	0.23
a-AAA	1.19 ± 0.05	1.27 ± 0.04	0.64 ± 0.01	0.39 ± 0.06	1.32 ± 0.09	0.96	0.14
Gly	3.25 ± 0.09	5.86 ± 0.17	6.13 ± 0.10	1.17 ± 0.01	3.48 ± 0.17	3.98	0.31
Ala	22.70 ± 0.93	26.48 ± 0.20	26.86 ± 0.45	4.72 ± 0.03	8.63 ± 0.49	17.88	1.34
Cit	nd[d]	nd	nd	nd	0.11 ± 0.00	0.02	0.01
a-ABA	nd	0.04 ± 0.00	nd	0.12 ± 0.01	nd	0.03	0.01
Val[e]	1.16 ± 0.10	1.21 ± 0.07	1.76 ± 0.17	0.41 ± 0.04	0.84 ± 0.05	1.07	0.25
Cys	1.58 ± 0.03	1.06 ± 0.06	6.32 ± 0.33	8.42 ± 0.05	0.54 ± 0.22	3.58	0.47
Met[e]	0.04 ± 0.03	0.60 ± 0.05	0.06 ± 0.01	0.22 ± 0.04	0.22 ± 0.26	0.23	0.31
Cysthi	1.76 ± 0.09	3.56 ± 0.09	1.89 ± 0.00	0.53 ± 0.05	1.06 ± 0.23	1.76	0.31
Ile[e]	nd	0.30 ± 0.04	0.37 ± 0.26	0.27 ± 0.02	0.23 ± 0.15	0.23	0.35
Leu[e]	0.32 ± 0.04	0.21 ± 0.07	0.49 ± 0.34	nd	0.20 ± 0.11	0.24	0.43
Tyr	0.39 ± 0.03	0.25 ± 0.06	0.99 ± 0.22	0.12 ± 0.03	0.29 ± 0.15	0.41	0.32
Phe[e]	0.08 ± 0.00	0.32 ± 0.09	0.19 ± 0.06	0.05 ± 0.04	0.09 ± 0.03	0.15	0.13
b-Ala	0.62 ± 0.03	0.42 ± 0.00	0.67 ± 0.01	0.10 ± 0.01	nd	0.36	0.04
b-AiBA	0.48 ± 0.04	0.14 ± 0.01	2.16 ± 0.01	0.27 ± 0.00	0.32 ± 0.02	0.67	0.05
g-ABA	0.69 ± 0.05	7.85 ± 0.02	11.63 ± 0.12	2.74 ± 0.11	0.16 ± 0.00	4.62	0.20
Trp[e]	nd	nd	nd	nd	nd	0.00	–
$EOHNH_2$	1.34 ± 0.05	3.98 ± 0.01	1.68 ± 0.02	1.46 ± 0.01	0.39 ± 0.02	1.77	0.07
NH_3	1.19 ± 0.04	1.70 ± 0.03	2.99 ± 0.04	1.46 ± 0.02	0.41 ± 0.02	1.55	0.08
Hylys	0.30 ± 0.00	0.29 ± 0.00	0.30 ± 0.01	0.43 ± 0.00	0.29 ± 0.00	0.32	0.01
Orn	32.74 ± 2.22	25.46 ± 0.25	12.55 ± 0.11	3.72 ± 0.09	16.84 ± 0.96	18.26	2.81
Lys[e]	3.57 ± 0.39	4.90 ± 0.12	6.21 ± 0.11	1.35 ± 0.08	2.89 ± 0.09	3.79	0.50
1Mehis	nd	nd	nd	nd	nd	0.00	–
His[e]	4.60 ± 0.58	1.65 ± 0.03	2.44 ± 0.18	0.23 ± 0.02	0.72 ± 0.05	1.93	0.70
3Mehis	nd	nd	nd	nd	0.02 ± 0.03	0.00	0.03
Ans	nd	nd	nd	nd	nd	0.00	–
Car	1.14 ± 0.80	1.04 ± 0.17	0.56 ± 0.40	1.03 ± 0.55	0.28 ± 0.09	0.81	1.23
Arg[e]	2.36 ± 0.34	0.38 ± 0.04	1.27 ± 0.15	0.47 ± 0.06	2.54 ± 0.12	1.40	0.46
Hypro	nd	nd	nd	nd	nd	0.00	–
Pro	4.76 ± 0.14	8.47 ± 0.23	8.97 ± 0.10	1.86 ± 0.03	5.27 ± 0.21	5.87	0.41
Tot	161.09 ± 6.24	168.43 ± 0.24	147.06 ± 0.09	55.69 ± 1.37	71.67 ± 3.10	120.9	8.18
$LSD_{0.05}$	0.98	0.20	0.40	0.23	0.61	0.25	–

[a] P-ser; D,L-O-Phosphoserine, Tau; Taurine, PEA; O-Phosphoethanolamine, Urea; Urea, Asp; L-Aspartic acid, Thr; L-Threonine, Ser; L-Serine, Glu; L-Glutamic Acid, Sar; Sarcosine, a-AAA; D,L-α-Aminoadipic Acid, Gly; Glycine, Ala; L-Alanine, Cit; L-Citrulline, a-ABA; L-α-Amino-n-Butyric Acid, Val; L-Valine, Cys; L-Cystine, Met; L-Methionine, Cysthi; L-Cystathionine, Ile; L-Isoleucine, Leu; L-Leucine, Tyr; L-Tyrosine, Phe; L-Phenylalanine, b-Ala; β-Alanine, b-AiBA; D,L-β-Amino-i-Butyric Acid, g-ABA; γ-AminoButyric Acid, Trp; L-Tryptophan, $EOHNH_2$; Ethanolamine, NH_3; Ammonia, Hylys; D,L & allo-Hydroxylysine, Orn; L-Ornithine, Lys; L-Lysine, 1Mehis; L-1-Methylhistidine, His; L-Histidine, 3Mehis; L-3-Methylhistidine, Ans; L-Anserine, Car; L-Carnosine, Arg; L-Arginine, Hypro; L-Hydroxyproline, Pro; L-Proline, Tot; Total.

[b] Values represent mean ± SD based on three experiments.

[c] Reported in mg/g dried plant material.

[d] nd: not detected.

[e] Essential amino acids.