

## Analysis and Comparison of the Amino Acids in Seven Strains of White *Flammulina velutipes*

Airong Song<sup>1</sup>, Lizhong Guo<sup>1</sup>, Jianwu Wang<sup>2</sup> and Jianshui Bi<sup>3</sup>

<sup>1</sup>Food Science Department, Laiyang Agricultural College, Laiyang 265200; <sup>2</sup>Lin He, An Qui, Shandong; <sup>3</sup>Department of Agricultural Technology, Laiyang, Shandong; P.R. China

**ABSTRACT:** The amino acid contents of seven white color strains of *Flammulina velutipes* were determined. Mycelium of the seven strains, grown in liquid culture, contained eight essential amino acids. However, the aromatic amino acids were relatively low. The eight essential amino acids were higher than or almost the same compared to three edible proteins ( $\alpha$ -tyroprotein, ovalbumin and soy sphaero-protein). The ratios of side chain amino acid to aromatic amino acids in seven strains were higher than those of three edible proteins and four agricultural products (rice, wheat, wheat flour and maize).

### 1 INTRODUCTION

*Flammulina velutipes*, also called the winter mushroom, is very popular with high nutrition and medical application, in China. In recent years, the yellow strains have become less popular than the white varieties and are produced less and less by farmers. In order to satisfy market requirements, we bred six white color strains of *Flammulina velutipes* and analyzed them and a control strain from Japan for their amino acid contents. Seventeen amino acids were abundant in the strains, especially lysine, arginine and glutamic acid.

## 2 MATERIALS AND METHODS

### 2.1 Strains

The white color strains were bred during 1992-94 at Laiyang Agricultural College. The crosses were numbered 1-6. Strain number 7 was a control obtained from Japan.

### 2.2 Mycelial culture

All cultures were maintained on potato dextrose agar (PDA). The fermentation medium contained the following ingredients (per liter): maize powder (30 g), glucose (10 g), sucrose (20 g),  $\text{KH}_2\text{PO}_4$  (1.5 g),  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  (0.75 g), wheat bran (30 g), vitamin  $\text{B}_2$  (0.5 g). Vitamin  $\text{B}_2$  was added after sterilization. The medium pH was 7.0. Mycelial plugs were inoculated into 500 ml flasks containing 100 ml fermentation medium. The inoculated flasks were placed on a rotary shaker at 100 rpm,  $25^\circ\text{C} \pm 1^\circ\text{C}$  for six days. The mycelium then was filtered, washed with sterile, distilled water, vacuum filtered, dried and weighed. The experiment was repeated 3 times. For the second fermentation, 1000 ml flasks containing 400 ml medium were inoculated and incubated under the same conditions as above.

### 2.3 Methods for measurement

The dried mycelium was hydrolysed for 24 hr at  $110^\circ\text{C}$  in 6N HCl. A 835-50 automatic amino acid analyser was used to quantify the amino acids in the seven strains tested.

## 3 RESULTS AND DISCUSSION

All seven *Flammulina velutipes* tested contained 17 amino acids (except tryptophane) and all contained the eight essential amino acids (Table 1). Considerable variation in amount of amino acids present was observed in different strains. It would appear that the metabolism of amino acids is complicated in *Flammulina velutipes*.

Table 1. Amino acid contents in the mycelium of seven white strains of *Flammulina velutipes*.

Amino acids	Strains						
	1	2	3	4	5	6	7
	----- g per 100 g dry mycelium -----						
Asp	1.87	1.47	1.41	1.48	1.32	1.48	1.25
Thr	0.92	0.76	0.78	0.80	0.72	0.83	0.71
Ser	1.03	0.80	0.84	0.80	0.74	0.87	0.74
Glu	2.74	2.08	2.11	2.20	1.93	2.22	1.85
Gly	0.94	0.71	0.74	0.72	0.67	0.78	0.65
Ala	1.13	0.96	0.92	0.99	0.89	1.00	0.84
Cys	0.29	0.23	0.20	0.23	0.19	0.21	0.23
Val	1.32	1.08	1.06	1.10	1.10	1.24	1.06
Met	1.22	0.97	1.35	0.98	1.10	1.20	1.64
Ile	0.80	0.89	0.72	0.62	0.57	0.69	0.60
Leu	1.45	1.14	1.21	1.11	1.07	1.21	1.01
Tyr	0.50	0.43	0.44	0.51	0.42	0.46	0.42
Phe	0.78	0.72	0.66	0.83	0.70	0.72	0.66
Lys	0.93	0.69	0.79	0.63	0.50	0.64	0.69
His	0.29	0.21	0.27	0.24	0.22	0.26	0.25
Arg	1.01	0.82	0.82	0.86	0.70	0.85	0.73
Pro	0.76	0.69	0.60	0.50	0.57	0.69	0.48

Strain No. 1 produced the highest quantity of whole and essential amino acids (17.98 g and 7.42 g, respectively, Table 2). Amino acid contents in the bred strains were higher than that of the control except for No. 5. Strains 1, 3 and 6 were all higher than the control in essential amino acids. The side chain amino acid contents of all the strains were higher than the control. Strain 1 was the highest with 3.57 g per 100 g dry mycelium. Strain 4 contained the highest level of aromatic amino acid (1.34 g). Strain 1 was the highest in lysine, arginine and glutamic acid (0.93 g, 1.01 g, 2.47 g, respectively, in 100 g mycelium). The ratios of the side chain amino acids to aromatic amino acids of all the strains were higher than the control except for strains 4 and 5. Strain 1 was the highest with 2.79 g/100 g dry mycelium (Table 2).

The ratio of essential amino acids (E) to nonessential amino acids (N) or essential amino acids (E) to whole amino acids (E+N) is the important standard to judge food nutrition, according to the principle proposed by FAO and WHO (FAO/WHO 1973). To be a nutritinous food, the E/N ratio should be higher than 0.6 and E should be about 40%. The seven white color strains of *Flammulina velutipes* have abundant proteins, E% is over 40, and the E/N is over 0.6 (Table 3). However, the quality of the proteins in the bred strains is somewhat lower than that of the control strain.

Tests showed that the seven *Flammulina velutipes* were abundant in essential amino acids, side chain amino acids, arginine, lysine and glutamic acid. Nearly all of the strains have a higher quantity of side chain amino acids and arginine in comparison to those of three edible proteins (Table 4). Strain 6 was the highest in side chain amino acid content (20.4%). Strain 3 was highest in lysine (5.3%) while strain 4 was the highest in arginine (5.9%). Strain 1 was the highest in glutamic acid (15.2%).

The results also indicated that the ratio of side chain amino acids to aromatic amino acids was higher than that of the edible proteins and four agricultural products tested in this experiment (Table 5). Fisccher (1975, 1976) discovered that the malfunction of the liver and cirrhosis of the liver were caused by abnormal metabolism of amino acids, i.e., the decrease of side chain amino acid and the increase of aromatic amino acids in plasma. Consequently, Fisccher (1975, 1976) suggested that liver disease severity in patients could be reduced by injecting a glucose/amino acid mixture containing high levels of side chain amino acids and low concentrations of aromatic amino acids. The white color *Flammulina velutipes* selected in our College are characterized by containing high quantities of side chain amino acids and low levels of aromatic amino acids. Therefore, we suggest that the amino acids present in the strains we developed could have a medical use in treating liver diseases. This may, ultimately, broaden the use of *Flammulina velutipes* in medicine.

Table 2. Comparison of contents of amino acids extracted from the mycelium of seven white color strains of *Flammulina velutipes*.

Amino acids	Strains						
	1	2	3	4	5	6	7
	----- g per 100g dry mycelium -----						
Amino acid	17.98	14.65	14.92	14.60	13.41	15.35	13.81
Essential amino acids	7.42	6.25	6.57	6.07	5.76	6.53	6.37
Essential amino acids/ amino acid	41.27	42.66	44.03	41.58	42.95	42.54	46.13
Side chain amino acids	3.57	3.11	2.99	2.83	2.74	3.14	2.67
Aromatic amino acids	1.28	1.15	1.10	1.34	1.12	1.18	1.08
Lysine	0.93	0.69	0.79	0.63	0.50	0.64	0.69
Argine	1.01	0.82	0.82	0.86	0.70	0.85	0.73
Glutamic acid	2.74	2.08	2.11	2.20	1.93	2.22	1.85

Table 3. Comparison of proteins in seven white color strains of *Flammulina velutipes*.

Amino acids	Strains							FAO/WHO ratio of essential amino acid <sup>1</sup>
	1	2	3	4	5	6	7	
Thr	128	130	130	138	135	135	128	4.0
Lys	93	85	96	79	68	76	91	5.5
Val	146	148	142	150	164	162	154	5.0
Ile	110	153	120	105	108	113	108	4.0
Leu	116	111	116	209	114	113	104	7.0
Phe	72	82	73	95	86	78	80	6.0
Met	194	189	257	191	234	223	340	3.5
Essential amino acid/amino acid (E%) <sup>2</sup>	41.3	42.7	44.0	41.6	43.0	42.5	46.1	40%
Essential amino acid/ nonessential amino acid (E/N) <sup>3</sup>	0.70	0.74	0.79	0.71	0.75	0.74	0.86	0.6

<sup>1</sup>Ratio of essential amino acid E% and E/N is based on that proposed by FAO/WHO (1973).

<sup>2</sup>Ratio of essential amino acid = Essential amino acid/Amino acid x 100.

<sup>3</sup>Amino acid score = ratio of essential amino acid/ratio of nonessential amino acid (FAO/WHO) x 100.

Table 4. Comparison of amino acids and three edible proteins in the mycelium of seven white color strains of *Flammulina velutipes*.

Amino acid type	Strains							a-t <sup>1</sup>	soy-s <sup>2</sup>	protein
	1	2	3	4	5	6	7			
Essential amino acid/ amino acid	41.3	42.7	44.0	41.6	43.0	42.5	46.1	38.1	43.9	39.7
Side chain amino acid/ amino acid	19.9	21.2	20.0	19.4	20.4	20.5	19.3	18.9	22.5	20.7
Aromatic amino acid/ amino acid	7.1	7.9	7.4	9.2	8.4	7.7	7.8	10.0	10.6	10.0
Lysine/amino acid %	5.2	4.7	5.3	4.3	3.7	4.2	5.0	8.2	6.0	7.3
Arginine/amino acid %	5.6	5.6	5.5	5.9	5.2	5.5	5.3	4.0	5.0	7.8
Glutamic acid/ amino acid %	15.2	14.2	14.1	15.1	14.4	14.5	13.4	20.7	14.6	19.8

<sup>1</sup>Alpha-tyro-ovalbumin; <sup>2</sup>soy sphaero-protein.

Table 5. Comparison of ratios of amino acids in seven *Flammulina velutipes*, edible proteins and four agricultural products.

Protein source	Strains/items	Side chain amino acid/aromatic amino acid
Mycelium	1	2.79
	2	2.70
	3	2.72
	4	2.11
	5	2.45
	6	2.66
	7	2.47
Edible proteins	A-tyroprotein	1.90
	Ovalbumin	2.12
	Soy sphaero-protein	2.07
Agricultural products <sup>1</sup>	Rice	2.36
	Wheat	1.80
	Fine wheat flour	1.86
	Maize	2.49

<sup>1</sup>Zhou 1981.

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