Hindawi
Journal of Food Quality
Volume 2022, Article ID 3618002, 10 pages
https://doi.org/10.1155/2022/3618002

Research Article

Comparison of the Nutritional and Taste Characteristics of 5 Edible Fungus Powders Based on the Composition of Hydrolyzed Amino Acids and Free Amino Acids

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Received 28 January 2022; Revised 22 February 2022; Accepted 2 March 2022; Published 7 April 2022

Academic Editor: Tao Feng

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The nutritional characteristics and taste of some edible fungus powders were scientifically evaluated and compared. Five common edible fungus powders were used as test materials (*Agrocybe chaxinggu* edible fungus powder, *Pleurotus citrinopileatus* edible fungus powder, *Flammulina velutipes* edible fungus powder, *Lentinus edodes* edible fungus powder, and *Hericium erinaceus* edible fungus powder). The hydrolyzed amino acid and free amino acid content were measured by an automatic amino acid analyzer, and the ratios of hydrolyzed amino acid and free amino acid components and the taste characteristics of these eatables were systematically compared. The results showed that the total amount of hydrolyzed amino acids contained in the 5 edible fungus powders was between 2.583 and 14.656 g/100 g. The total amount of free amino acids contained in the 5 edible fungus powders was between 0.550 and 2.612 g/100 g. Comparative analysis of the mass fractions and composition of amino acids indicated that *Pleurotus citrinopileatus* edible fungus powder best met the ideal protein standard. The taste characteristics of protein were evaluated by calculating the taste active value (TAV) of taste-producing free amino acids. The most significant TAV values of the 5 edible fungus powders appeared in glutamic acid, and this amino acid is an umami amino acid. Principal component analysis (PCA) suggested that four principal components could reflect all the information on the free amino acids with a total cumulative variance contribution rate of 100%, and three principal components could reflect most of the information on the hydrolyzed amino acids with a total cumulative variance contribution rate of 99.143%, which could represent the main trends of free amino acids and hydrolyzed acids in edible fungus powder. The comprehensive evaluation model was established, and the comprehensive score indicated that *Agrocybe chaxinggu* edible fungus powder had the best comprehensive amino acid quality.

1. Introduction

Edible funguses are widely grown all over the world. There are at least 2,000 species of edible funguses in the world, of which about 200 are wild edible funguses [1]. China is the largest producer of edible funguses in the world, accounting for two-thirds of the world's production [2, 3]. Edible funguses are widely cultivated for their medicinal and nutritional value. Some edible funguses have been reported as therapeutic foods, useful in preventing diseases such as hypertension, hypercholesterolemia, atherosclerosis, or cancer [4–7]. Edible funguses are valuable health foods, low in calories, lipids, and essential fatty acids, and high in vegetable proteins, minerals, and vitamins [8]. As a delicacy, edible funguses have unique umami, texture, and increasingly high-rated nutritive value. Umami is produced by glutamic acid, ribonucleotide and chemicals that make edible funguses tasty and are widely used in food preparation [2].

An amino acid is a biologically active substance that plays an important role in human metabolism. Its composition and content are important indicators for evaluating the nutritional value of edible funguses [9, 10]. Free amino acids (FAA), also known as nonprotein amino acids, are an important class of taste active ingredients [11], and their content and types are often used as important indicators for food nutritional value and taste and taste evaluation [12]. Some studies have shown that the main taste substances that have a significant impact on the taste of edible funguses are nucleotides, soluble sugars, organic acids, free amino acids, and other taste substances. Among them, free amino acids play an extremely important role in the presentation of the taste and deliciousness of edible funguses [13]. The typical umami taste of edible funguses is attributed to aspartic acid and glutamate [2]. Umami not only alleviates salty, sour or bitter tastes and improves the perception of sweetness, it also reduces the pungent meaty smell and the earthy taste [14, 15]. At present, the analytical methods for amino acids in edible funguses include ninhydrin colorimetry [16], high performance liquid chromatography [14, 17, 18], gas chromatography [19], gas chromatography-mass spectrometry [6, 20], nuclear magnetic resonance [21], amino acid analyzers [22–27], and high performance liquid chromatography-triple quadrupole mass spectrometry [28]. In the present study, the amino acid analyzer was used to analyze the nutritional characteristics of hydrolyzed amino acids and free amino acids of five common edible funguses powder, and their differences in nutritional and taste components were compared. The research results not only provide scientific data for revealing the nutritional value and taste characteristics of edible funguses, but also provide a scientific basis for guiding people to establish a scientific and healthy diet structure.

2. Materials and Methods

2.1. Materials and Reagents. Aspartic acid, threonine, serine, glutamic acid, glycine, alanine, valine, methionine, isoleucine, leucine, tyrosine, phenylalanine, lysine, histidine, arginine, and proline mixed standard solution were obtained from Wako Pure Chemical Industries, Ltd. (2.5 μmol/mL, Tokyo, Japan). Water was purified using a Milli-Q-System (Millipore, Guyancourt, France). Ethanol was HPLC grade and was purchased from Merck (Darmstadt, Germany). Sodium citrate dihydrate, citric acid monohydrate, sodium chloride, sodium hydroxide, sodium borohydride, and hydrochloric acid were premium grade pure and were purchased from Beijing Chemical Reagent Factory (Beijing, China). Anhydrous sodium acetate, ninhydrin, ethylene glycol monomethyl ether, acetic acid, and phenol were analytical grade and were purchased from the Guangfu Fine Chemical Research Institute (Tianjin, China).

Agrocybe chaxinggu edible fungus powder, *Pleurotus citrinopileatus* edible fungus powder, *Flammulina velutipes* edible fungus powder, *Lentinus edodes* edible fungus powder, and *Hericium erinaceus* edible fungus powder were supplied by Henan Longfeng Edible Funguses Industry Research Institute.

2.2. Methods

2.2.1. Determination of Hydrolyzed Amino Acids. Refer to GB 5009.124-2016 [29] for the determination of hydrolyzed amino acids. 0.5 g of each sample was hydrolyzed by an electric heating blast drying oven (Boxun GZX-9240MBE, China) with 10 mL of 6 mol/L hydrogen chloride at 110°C for 22 h under a nitrogen atmosphere, and then filtered through a 0.45 mm membrane filter prior to analysis. The amino acid profiles of each sample were determined by an automatic amino acid analyzer (Hitachi L-8900, Japan). All determinations were carried out in triplicate.

2.2.2. Determination of Free Amino Acids. Refer to the first method in GB/T 30987-2020 [30] for the determination of free amino acids. 0.5 g of the sample was diluted with 100 mL of boiling water. The sample was water bathed by a water bath constant temperature oscillator (Runhua SHA-B, China) at 95°C for 10 min. and then filtered through a 0.45 mm membrane filter prior to analysis. The amino acid profiles of each sample were determined by an automatic amino acid analyzer (Hitachi L-8900, Japan). All determinations were carried out in triplicate.

2.3. Statistical Analysis. All analyses were conducted in triplicate. The results reported were the average of these three replicates. Normal distribution tests of multielements and PCA analysis were performed with SPSS 25.0 software (SPSS, IBM Corp., USA).

3. Results and Discussion

3.1. Hydrolyzed Amino Acid Concentrations in 5 Edible Fungus Powders. The hydrolyzed amino acid is to hydrolyze the protein, polypeptide, and other amino acid chains in the plant to be tested into a single amino acid through acid hydrolysis. Therefore, the hydrolyzed amino acid can fully reflect the kind and content of all single amino acids in the sample. The hydrolyzed amino acid composition and content of 5 kinds of edible fungus powder are shown in Table 1. Results showed that 15 hydrolyzed amino acids were present in all samples tested. The total amount of hydrolyzed amino acids contained in the 5 edible fungus powders was between 2.583 and 14.656 g/100 g. The total hydrolyzed amino acid content of *Pleurotus citrinopileatus* edible fungus powder was the highest, reaching 14.656 g/100 g, and the total hydrolyzed amino acid content of *Hericium erinaceus* edible fungus powder was the lowest, at 2.583 g/100 g. Glutamic acid was the most abundant among the 5 kinds of edible fungus powder, accounting for 17.41%, 19.75%, 25.16%, 24.92%, and 16.72% of the total hydrolyzed amino acids, respectively.

3.2. Free Amino Acid Concentrations in 5 Edible Fungus Powders. Free amino acids refer to amino acids that exist in a free state in plants as a single amino acid molecule and can be directly absorbed and utilized. The free amino acid composition and content of 5 kinds of edible fungus powder are shown in Table 2. The total amount of free amino acids

Table 1: Contents* of hydrolyzed amino acids in 5 kinds of edible fungus powders.

Compound	*Agrocybe chaxinggu* edible fungus powder	*Pleurotus citrinopileatus* edible fungus powder	*Flammulina velutipes* edible fungus powder	*Lentinus edodes* edible fungus powder	*Hericium erinaceus* edible fungus powder
Aspartic acid and asparagine	1.571 ± 0.015	0.613 ± 0.001	0.531 ± 0.002	0.737 ± 0.002	0.247 ± 0.005
Threonine	0.744 ± 0.012	0.510 ± 0.009	0.147 ± 0.003	0.192 ± 0.002	0.107 ± 0.005
Serine	0.768 ± 0.003	0.469 ± 0.006	0.280 ± 0.006	0.399 ± 0.004	0.099 ± 0.003
Glutamic acid and glutamine	2.536 ± 0.012	2.894 ± 0.001	2.198 ± 0.031	2.969 ± 0.030	0.432 ± 0.001
Glycine	0.799 ± 0.008	0.867 ± 0.004	0.468 ± 0.004	0.650 ± 0.002	0.165 ± 0.003
Alanine	1.491 ± 0.004	1.427 ± 0.059	1.065 ± 0.024	1.859 ± 0.014	0.414 ± 0.005
Valine	1.021 ± 0.014	1.202 ± 0.023	0.585 ± 0.002	0.809 ± 0.014	0.207 ± 0.012
Methionine	0.022 ± 0.002	0.113 ± 0.011	ND	ND	ND
Isoleucine	0.583 ± 0.011	0.677 ± 0.003	0.301 ± 0.004	0.423 ± 0.005	0.068 ± 0.002
Leucine	1.379 ± 0.017	1.703 ± 0.037	0.821 ± 0.001	1.135 ± 0.009	0.298 ± 0.002
Tyrosine	0.507 ± 0.004	0.636 ± 0.008	0.414 ± 0.001	0.406 ± 0.015	0.111 ± 0.000
Phenylalanine	0.714 ± 0.010	0.849 ± 0.004	0.537 ± 0.003	0.567 ± 0.025	0.112 ± 0.006
Lysine	0.754 ± 0.002	1.082 ± 0.006	0.622 ± 0.002	0.710 ± 0.005	0.102 ± 0.001
Histidine	0.300 ± 0.004	0.410 ± 0.005	0.217 ± 0.003	0.257 ± 0.003	0.057 ± 0.003
Arginine	0.943 ± 0.009	1.204 ± 0.027	0.554 ± 0.009	0.799 ± 0.012	0.165 ± 0.001
Proline	0.434 ± 0.016	ND	ND	ND	ND
Total	14.567 ± 0.024	14.656 ± 0.287	8.739 ± 0.016	11.912 ± 0.092	2.583 ± 0.010

*Value (g/100 g) = mean ± SD ($n = 3$). ND: not detectable.

Table 2: Contents* of free amino acids in 5 kinds of edible fungus powders.

Compound	*Agrocybe chaxinggu* edible fungus powder	*Pleurotus citrinopileatus* edible fungus powder	*Flammulina velutipes* edible fungus powder	*Lentinus edodes* edible fungus powder	*Hericium erinaceus* edible fungus powder
Aspartic acid	0.070 ± 0.001	0.016 ± 0.000	0.018 ± 0.000	0.022 ± 0.000	0.016 ± 0.001
Threonine	0.139 ± 0.003	0.286 ± 0.000	0.373 ± 0.001	0.327 ± 0.004	0.037 ± 0.001
Serine	0.079 ± 0.002	0.107 ± 0.000	0.068 ± 0.002	0.015 ± 0.000	0.004 ± 0.000
Glutamic acid	0.505 ± 0.003	0.396 ± 0.000	0.739 ± 0.003	0.448 ± 0.007	0.100 ± 0.002
Glycine	0.047 ± 0.000	0.032 ± 0.000	0.049 ± 0.000	0.022 ± 0.000	0.019 ± 0.001
Alanine	0.326 ± 0.002	0.207 ± 0.000	0.409 ± 0.001	0.135 ± 0.002	0.085 ± 0.003
Valine	0.164 ± 0.002	0.117 ± 0.000	0.118 ± 0.000	0.053 ± 0.001	0.047 ± 0.002
Methionine	ND	0.007 ± 0.000	ND	ND	ND
Isoleucine	0.101 ± 0.001	0.033 ± 0.000	0.060 ± 0.000	0.012 ± 0.000	0.022 ± 0.000
Leucine	0.168 ± 0.002	0.063 ± 0.000	0.103 ± 0.000	0.017 ± 0.000	0.064 ± 0.002
Tyrosine	0.064 ± 0.001	0.086 ± 0.001	0.159 ± 0.000	0.032 ± 0.001	0.038 ± 0.001
Phenylalanine	0.115 ± 0.002	0.131 ± 0.000	0.216 ± 0.001	0.046 ± 0.000	0.046 ± 0.003
Lysine	0.066 ± 0.002	0.079 ± 0.000	0.151 ± 0.001	0.035 ± 0.000	0.007 ± 0.000
Histidine	0.027 ± 0.000	0.028 ± 0.000	0.052 ± 0.000	0.009 ± 0.000	0.008 ± 0.000
Arginine	0.106 ± 0.002	0.062 ± 0.000	0.057 ± 0.001	0.055 ± 0.001	0.024 ± 0.001
Proline	0.026 ± 0.002	ND	0.039 ± 0.002	ND	0.034 ± 0.002
Total	2.003 ± 0.018	1.651 ± 0.001	2.612 ± 0.005	1.228 ± 0.017	0.550 ± 0.018

*Value (g/100 g) = mean ± SD ($n = 3$). ND: not detectable.

contained in the 5 edible fungus powders was between 0.550 and 2.612 g/100 g. The total free amino acid content of *Flammulina velutipes* edible fungus powder was the highest, reaching 2.612 g/100 g, and the total free amino acid content of *Hericium erinaceus* edible fungus powder was the lowest, at 0.550 g/100 g. Glutamic acid was the most abundant among the 5 kinds of edible fungus powders, accounting for 25.21%, 23.99%, 28.29%, 36.48%, and 18.18% of the total free amino acids, respectively.

3.3. The Difference in the Ratio of Essential Amino Acids and Nonessential Amino Acids. In order to scientifically evaluate the component structure of hydrolyzed amino acids, indicators such as the ratio of essential amino acids (EAAs) to nonessential amino acids (NEAAs) have been introduced. According to the essential amino acid model of protein nutritional value proposed by the World Health Organization (WHO) and the United Nations Food and Agriculture Organization (FAO) in 1973, the EAA/(EAA + NEAA)

Table 3: Comparative analysis of the mass fractions and composition of amino acids in 5 edible fungus powders.

Sample	EAA/NEAA	EAA/(EAA + NEAA)
Agrocybe chaxinggu edible fungus powder	55.81	35.82
Pleurotus citrinopileatus edible fungus powder	72.03	41.87
Flammulina velutipes edible fungus powder	52.62	34.48
Lentinus edodes edible fungus powder	47.48	32.20
Hericium erinaceus edible fungus powder	52.85	34.58

Table 4: Flavored amino acid content (g/100 g) in 5 kinds of edible fungus powders.

Sample	Umami amino acids	Sweet amino acids	Bitterness amino acids	Tasteless amino acids
Agrocybe chaxinggu edible fungus powder	0.574	0.616	0.682	0.131
Pleurotus citrinopileatus edible fungus powder	0.412	0.633	0.441	0.163
Flammulina velutipes edible fungus powder	0.757	0.969	0.606	0.310
Lentinus edodes edible fungus powder	0.469	0.499	0.193	0.067
Hericium erinaceus edible fungus powder	0.115	0.179	0.211	0.045

Table 5: The TAV of free amino acid in 5 kinds of edible fungus powders.

Compound	Taste characteristics	Taste threshold (mg/100 g) [34]	TAV of 5 kinds of edible fungus powders				
			Agrocybe chaxinggu	*Pleurotus citrinopileatus*	*Flammulina velutipes*	*Lentinus edodes*	*Hericium erinaceus*
Aspartic acid	Umami	3.00	23.22	5.30	6.03	7.29	5.24
Threonine	Sweet	260.00	0.53	1.10	1.44	1.26	0.14
Serine	Sweet	150.00	0.52	0.72	0.45	0.10	0.02
Glutamic acid	Umami	5.00	100.93	79.30	147.84	89.50	19.95
Glycine	Sweet	110.00	0.42	0.29	0.45	0.20	0.17
Alanine	Sweet	60.00	5.44	3.45	6.82	2.25	1.42
Valine	Bitterness	150.00	1.09	0.78	0.78	0.35	0.32
Methionine	Bitterness	30.00	0.00	0.24	0.00	0.00	0.00
Isoleucine	Bitterness	90.00	1.13	0.37	0.67	0.14	0.25
Leucine	Bitterness	380.00	0.44	0.17	0.27	0.04	0.17
Tyrosine	Tasteless	260.00	0.25	0.33	0.61	0.12	0.15
Phenylalanine	Bitterness	150.00	0.77	0.87	1.44	0.31	0.31
Lysine	Tasteless	50.00	1.33	1.59	3.02	0.69	0.14
Histidine	Bitterness	20.00	1.34	1.39	2.60	0.44	0.38
Arginine	Bitterness	10.00	10.64	6.23	5.73	5.53	2.38
Proline	Sweet	300.00	0.09	0.00	0.13	0.00	0.11

value in an ideal protein should reach about 40%, and the EAA/NEAA value should be above 60% [31]. The results (Table 3) showed that the value of EAA/(EAA + NEAA) was between 32.20% and 41.87%, and the value of EAA/NEAA was 47.48%–72.03%. In contrast, among the 5 kinds of edible fungus powders, *Lentinus edodes* edible fungus powder had the lowest EAA/(EAA + NEAA) and EAA/NEAA values, and *Pleurotus citrinopileatus* edible fungus powder best met the ideal protein standard.

3.4. The Difference in Taste Characteristics and Taste Activity Values. The determination of hydrolyzed amino acids was mainly to study their nutritional properties. The flavored amino acids in structural proteins are mostly in a combined state and have little effect on flavor, while free amino acids are mainly used to participate in the formation of taste substances. Therefore, the taste characteristics of free amino acids in the five test samples were compared, and they were divided into 4 categories: umami amino acids, sweet amino acids, bitterness amino acids, and tasteless amino acids [32]. The results (Table 4) showed that *Pleurotus citrinopileatus* edible fungus powder, *Flammulina velutipes* edible fungus powder, and *Lentinus edodes* edible fungus powder had the highest content of sweet amino acids. *Agrocybe chaxinggu* edible fungus powder and *Hericium erinaceus* edible fungus powder had the highest content of bitterness amino acids.

The absolute content and relative ratio of flavored amino acids may be closely related to the taste of the food. Therefore, the taste active value (TAV) of 16 amino acids in 5 kinds of test samples was analyzed and compared. TAV is the ratio of the content of each taste amino acid in the sample to its corresponding taste threshold [33]. In general, when TAV > 1, the taste-producing substance is considered to have a significant impact on the taste-producing effect of the sample; when TAV < 1, it means that the substance has no significant taste-producing effect [34]. The results (Table 5) showed that among the 5 edible fungus powders, the TAV values of aspartic acid, glutamic acid, alanine, and arginine were also greater than 1. The TAV values of serine, glycine, methionine, leucine, tyrosine, and proline were also

Table 6: Correlation analysis of free amino acids in 5 kinds of edible fungus powders.

Amino acids	Aspartic acid	Threonine	Serine	Glutamic acid	Glycine	Alanine	Valine	Methionine	Isoleucine	Leucine	Tyrosine	Phenylalanine	Lysine	Histidine	Arginine	Proline
Aspartic acid	1															
Threonine	−0.320	1														
Serine	0.271	0.349	1													
Glutamic acid	0.200	0.783	0.502	1												
Glycine	0.519	0.333	0.680	0.819	1											
Alanine	0.385	0.457	0.624	0.888*	0.983**	1										
Valine	0.699	0.122	0.839	0.583	0.889*	0.799	1									
Methionine	−0.296	0.214	0.670	−0.101	−0.073	−0.106	0.195	1								
Isoleucine	0.842	−0.119	0.545	0.493	0.867	0.772	0.910*	−0.197	1							
Leucine	0.802	−0.276	0.493	0.353	0.807	0.702	0.860	−0.198	0.980**	1						
Tyrosine	−0.153	0.577	0.559	0.767	0.763	0.843	0.492	0.111	0.379	0.351	1					
Phenylalanine	0.007	0.557	0.682	0.808	0.856	0.908*	0.646	0.160	0.515	0.475	0.982**	1				
Lysine	−0.023	0.697	0.634	0.894*	0.833	0.906*	0.591	0.117	0.449	0.375	0.968**	0.981**	1			
Histidine	0.047	0.555	0.657	0.832	0.878	0.930*	0.655	0.100	0.546	0.501	0.978**	0.998**	0.983**	1		
Arginine	0.874	0.119	0.624	0.527	0.707	0.605	0.875	0.023	0.832	0.728	0.134	0.311	0.320	0.337	1	
Proline	0.146	−0.343	−0.173	0.118	0.419	0.431	0.159	−0.593	0.449	0.556	0.432	0.382	0.284	0.408	−0.102	1

Note: relevance is Pearson's type; *significant correlation ($p < 0.05$); **extremely significant correlation ($p < 0.01$).

Table 7: Results of principal component analysis.

Component	Initial eigenvalue			Rotate the sum of squares loading		
	Total	Variance (%)	Accumulate (%)	Total	Variance (%)	Accumulate (%)
1	9.241	57.759	57.759	7.125	44.532	44.532
2	3.455	21.592	79.351	5.259	32.869	77.402
3	2.183	13.645	92.996	1.916	11.977	89.378
4	1.121	7.004	100	1.699	10.622	100

Table 8: Contribution value of element principal component.

Amino acids	Component			
	1	2	3	4
Aspartic acid	0.432	0.854	0.178	−0.228
Threonine	0.417	−0.750	0.176	−0.482
Serine	0.745	−0.103	0.589	0.296
Glutamic acid	0.843	−0.301	−0.045	−0.443
Glycine	0.991	0.112	−0.064	−0.031
Alanine	0.984	−0.040	−0.148	−0.089
Valine	0.882	0.334	0.315	0.104
Methionine	0.037	−0.397	0.776	0.488
Isoleucine	0.809	0.587	−0.011	0.029
Leucine	0.743	0.634	−0.089	0.195
Tyrosine	0.814	−0.490	−0.256	0.176
Phenylalanine	0.902	−0.377	−0.131	0.163
Lysine	0.884	−0.454	−0.112	−0.017
Histidine	0.917	−0.344	−0.164	0.117
Arginine	0.675	0.510	0.443	−0.295
Proline	0.349	0.253	−0.847	0.311

less than 1. The TAV of free amino acid in *Agrocybe chaxinggu* edible fungus powder was between 0.00 and 100.93. The TAV of free amino acid in *Pleurotus citrinopileatus* edible fungus powder was between 0.00 and 79.30. The TAV of free amino acid in *Flammulina velutipes* edible fungus powder was between 0.00 and 147.84. The TAV of free amino acid in *Lentinus edodes* edible fungus powder was between 0.00 and 89.50. The TAV of free amino acid in *Hericium erinaceus* edible fungus powder was between 0.00 and 19.95. According to the TAV value, the most significant free amino acid that affects the taste of the 5 edible fungus powders that can be screened out was glutamic acid in the umami amino acid, followed by aspartic acid in umami amino acids, arginine in bitterness amino acids, and alanine in sweet amino acids. And *Flammulina velutipes* edible fungus powder has the most outstanding umami.

3.5. Correlation Analysis and PCA of Free Amino Acids. A correlation analysis was performed on the 16 free amino acid components of 5 edible fungus powders, and the results are shown in Table 6. There were positive correlations and negative correlations between amino acids, and most of them were positive. The results showed that there was a strong correlation between the free amino acids of the five edible fungus powders, which could be comprehensively evaluated by PCA.

PCA is a multivariate statistical analysis method that analyses a few variables which can reveal the internal structure sufficiently by studying the relationship between multiple original variables [35]. According to the rule that the characteristic value is greater than 1 and the cumulative variance contribution rate is greater than 80%, four principal component factors were obtained through rotation and extraction factors, and the total contribution rate was 100%, indicating that the experimental data can fully reflect the original information (Table 7).

The first principal component was mainly composed of glycine, alanine, histidine, phenylalanine, lysine, valine, glutamic acid, tyrosine, isoleucine, serine, leucine, and arginine. The second principal component was mainly composed of aspartic acid, leucine, isoleucine, and arginine. And the third principal component was mainly composed of methionine and serine (Table 8).

3.6. Correlation Analysis and PCA of Hydrolyzed Amino Acids. A correlation analysis was performed on the 16 hydrolyzed amino acid components of 5 edible fungus powders, and the results are shown in Table 9. The results showed that the correlation coefficients between most hydrolyzed amino acids were greater than 0.7, indicating that there were strong correlations among the 16 hydrolyzed amino acids in 5 kinds of edible fungus powders, so they could be further studied by PCA.

PCA was performed on the hydrolyzed amino acid content of the 5 samples, and the results are shown in Tables 10 and 11. It can be seen from Tables 10 and 11 that the cumulative contribution rate of the three principal components reaches 99.143%, indicating that three

Table 9: Correlation analysis of free amino acids in 5 kinds of edible funguses powder.

Amino acids	Aspartic acid	Threonine	Serine	Glutamic acid	Glycine	Alanine	Valine	Methionine	Isoleucine	Leucine	Tyrosine	Phenylalanine	Lysine	Histidine	Arginine	Proline
Aspartic acid	1															
Threonine	0.853	1														
Serine	0.953*	0.927*	1													
Glutamic acid	0.513	0.481	0.684	1												
Glycine	0.663	0.785	0.852	0.903*	1											
Alanine	0.576	0.444	0.692	0.948*	0.832	1										
Valine	0.607	0.783	0.817	0.875	0.995**	0.785	1									
Methionine	0.041	0.519	0.319	0.418	0.648	0.235	0.724	1								
Isoleucine	0.630	0.807	0.834	0.861	0.994**	0.769	0.999**	0.721	1							
Leucine	0.568	0.758	0.787	0.876	0.990**	0.780	0.999**	0.746	0.996**	1						
Tyrosine	0.515	0.688	0.734	0.889*	0.956*	0.734	0.964**	0.712	0.963**	0.967**	1					
Phenylalanine	0.573	0.714	0.779	0.910*	0.974**	0.777	0.975**	0.673	0.974**	0.975**	0.996**	1				
Lysine	0.435	0.612	0.673	0.917*	0.952*	0.777	0.962**	0.728	0.955*	0.970**	0.989**	0.985**	1			
Histidine	0.480	0.686	0.717	0.886*	0.969**	0.753	0.983**	0.769	0.979**	0.989**	0.988**	0.986**	0.993**	1		
Arginine	0.548	0.737	0.772	0.885*	0.988**	0.790	0.997**	0.746	0.993**	0.999**	0.966**	0.974**	0.974**	0.990**	1	
Proline	0.932*	0.817	0.824	0.178	0.414	0.245	0.369	−0.057	0.402	0.324	0.266	0.318	0.158	0.225	0.297	1

Note: relevance is Pearson's type; *significant correlation ($p < 0.05$); **extremely significant correlation ($p < 0.01$).

Table 10: Results of principal component analysis.

Component	Initial eigenvalue			Rotate the sum of squares loading		
	Total	Variance (%)	Accumulate (%)	Total	Variance (%)	Accumulate (%)
1	12.568	78.547	78.547	6.213	38.834	38.834
2	2.294	14.335	92.882	5.491	34.318	73.152
3	1.002	6.261	99.143	4.158	25.99	99.143

Table 11: Contribution value of element principal component.

Amino acids	Component		
	1	2	3
Aspartic acid	0.674	0.732	−0.100
Threonine	0.805	0.474	0.355
Serine	0.861	0.508	−0.018
Glutamic acid	0.889	−0.176	−0.419
Glycine	0.998	−0.017	−0.035
Alanine	0.805	−0.027	−0.562
Valine	0.994	−0.077	0.049
Methionine	0.657	−0.467	0.582
Isoleucine	0.996	−0.045	0.073
Leucine	0.989	−0.126	0.054
Tyrosine	0.964	−0.185	0.022
Phenylalanine	0.980	−0.126	−0.023
Lysine	0.952	−0.288	−0.037
Histidine	0.971	−0.232	0.047
Arginine	0.985	−0.152	0.036
Proline	0.436	0.889	0.131

Table 12: Comprehensive scores of 5 edible funguses powder.

Sample	Free amino acid		Hydrolyzed amino acid	
	Comprehensive score	Rank	Comprehensive score	Rank
Agrocybe chaxinggu edible fungus powder	2.040	1	2.027	1
Pleurotus citrinopileatus edible fungus powder	0.065	3	1.180	2
Flammulina velutipes edible fungus powder	0.733	2	−0.844	4
Lentinus edodes edible fungus powder	−1.424	5	−0.381	3
Hericium erinaceus edible fungus powder	−1.413	4	−1.979	5

components can represent the information of all hydrolyzed amino acids in 5 kinds of edible fungus powders and can better reflect the relationship of free amino acids in 5 kinds of edible fungus powders.

The first principal component was mainly composed of glycine, isoleucine, valine, leucine, arginine, phenylalanine, histidine, tyrosine, lysine, glutamic acid, serine, alanine, threonine, aspartic acid, and methionine. The second principal component was mainly composed of proline, aspartic acid, and serine. And the third principal component was mainly composed of methionine (Table 11).

3.7. Comprehensive Evaluation. A comprehensive evaluation model was established based on the contribution rates of the eigenvalues corresponding to the three principal components of hydrolyzed amino acids and the four principal components of free amino acids. The free amino acid model was $F = 0.445F_1 + 0.329F_2 + 0.120F_3 + 0.106F_4$. The hydrolyzed amino acid model was $F' = 0.392F_1' + 0.346F_2' + 0.262F_3'$. A comprehensive score was calculated for each sample, followed by ranking and evaluating the amino acid content of each sample. It can be seen from Table 12 that the comprehensive scores of hydrolyzed amino acids and free amino acids of *Agrocybe chaxinggu* edible fungus powder were greater than those of other varieties, indicating that the comprehensive quality of hydrolyzed amino acids and free amino acids of this variety was higher, and it is a variety with better amino acid quality.

4. Conclusions and Discussion

In this study, the composition and content of free amino acids and hydrolyzed amino acids of *Agrocybe chaxinggu* edible fungus powder, *Pleurotus citrinopileatus* edible fungus powder, *Flammulina velutipes* edible fungus powder, *Lentinus edodes* edible fungus powder, and *Hericium erinaceus* edible fungus powder were analyzed. The results showed that the total amount of hydrolyzed amino acids contained in the 5 edible fungus powders was between 2.583 and 14.656 g/100 g. The total amount of free amino acids contained in the 5 edible fungus powders was between

0.550 and 2.612 g/100 g. The total amount of hydrolyzed amino acids was relatively large, which may be caused by the simultaneous thermal degradation and Maillard reaction, which hydrolyzed macromolecular proteins or polypeptides into small molecular amino acids. Comparative analysis of the mass fractions and composition of amino acids indicated that *Pleurotus citrinopileatus* edible fungus powder best met the ideal protein standard. The delicious taste of edible fungus powder is determined by the balance and mutual influence of different free amino acids, which play an important role in the taste of edible fungus powder. In this study, the TAV of free amino acids of five edible fungus powders was evaluated. The TAV of amino acids is related to water solubility. Water-soluble amino acids may be partly due to hydrolysis, or may be due to water-solubility in nature, which was related to the structure and properties of the amino acids themselves [36]. The most significant free amino acid that affects the taste of the 5 edible fungus powders which can be screened out was the glutamic acid in the umami amino acid. And *Flammulina velutipes* edible fungus powder has the most outstanding umami. However, the amino acids alone might not be good enough to be responsible for the taste. Fatty acids might also contribute a lot in forming the taste. The taste of edible fungus powder was systematically evaluated, and the results of fatty acids need to be determined later [37]. PCA extracted four principal components from 16 free amino acids with a cumulative variance contribution rate of 100%, and extracted three principal components from 16 hydrolyzed amino acids with a cumulative variance contribution rate of 99.143%, which can better reflect the comprehensive information on the quality of the 5 edible fungus powders. A comprehensive evaluation model was established, and the comprehensive quality of amino acids in *Agrocybe chaxinggu* edible fungus powder was the best. This paper only studies the amino acid compositions and contents of 5 edible fungus powders at present. Further research will collect more edible fungus powder samples to determine their amino acid composition and content in order to establish a more detailed edible fungus powder quality evaluation system, laying a theoretical foundation for the development of edible fungus resources.

Data Availability

The data used to support the findings of this study are included within the article.

Disclosure

Jian Li and Junmei Ma are the co-first authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Jian Li and Junmei Ma contributed equally to this paper. YZ and SQM conceived and designed the study. JL and JMM performed the experiments. JL and JMM wrote the paper. YZ, SQM, and SSF reviewed and edited the manuscript. All authors read and approved the manuscript.

Acknowledgments

This work was supported by National Key Research and Development Program of China (Project no. 2018YFC1311400).

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