Progress in Nutrition 2020; Vol. 22, N. 1: 323-329 DOI: 10.23751/pn.v22i1.9023

Original article

Compositional and nutritional inventory of naturally mutant strain *Auricularia cornea* var. *Li*. edible mushroom from China

Rebecca R.J[1,3], *Jiachan Zhang*[2], *Wensheng Zhao*[4], *Yu Liu*[1], *Wasantha K.L*[3], *Shouxian Wang*[1]

[1]Institute of Plant and Environment Protection, Beijing Academy of Agriculture and Forestry Sciences, Beijing Engineering Research Center for Edible Mushroom, Key Laboratory of Urban Agriculture (North), Ministry of Agriculture, Beijing, China; [2]Beijing Key Lab of Plant Resource Research and Development, Beijing Technology and Business University, Beijing, China; [3]Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Sri Lanka –E.mail: wasanthk2011@gmail.com; [4]China Agricultural University, Haidian District, Beijing, China –E.mail: wangshouxian2002@163.com.

Summary. Auricularia cornea var. Li. is a natural mutation strain of A. cornea which has been preferred by consumers for its white colour, good taste with their pharmacological properties. Even though there are many reports about the cultivation technologies, to the best of our knowledge, very few studies have been performed on nutritional compositions of white species of Auricularia. Therefore, this study aimed at determining the nutritional compositions of A. cornea var. Li..Eighty percent of sawdust, 18% of wheat bran and 2% of lime were used as cultivation substrate. Results were obtained by the mean ± S.E of three independent determinations based on the dry weight. Total dietary fiber was the dominant compound (78.94 g/100g), followed by protein (8.68 g/100g), carbohydrates (6.31 g/100g), ash (2.43 g/100g) and fat (0.91 g/100g). Potassium (1121.66 mg/100g) was the most abundant mineral, followed by magnesium (143.23 mg/100g), calcium (108.97 mg/100g) and sodium (29.22 mg/100g) in tested samples. A. cornea var. Li. has been found to contain all the essential amino acids. Glutamic acid was recorded more than 13% of the total detected amino acid content and linoleic acid was recorded more than 43% of total detected fatty acid content in this study. Although this mushroom desired for its color and flavor, it has found to be a good source of total dietary fibers, proteins, trace functional minerals, and low fat content, making it an ideal component in healthy diets.

Key words: amino acid profile, *Auricularia fuscosuccinea*, *Auricularia polyticha*, fatty acid profile, macro nutrient, nutritional composition

Introduction

Auricularia is a widely-reaching species of edible fungus. This species is recognized by its earlike shape. *Auricularia* belongs to family Auriculariaceae. It can be observed mostly on dead woods and decaying logs (1). *Auricularia* is the fourth largest cultivated mushroom species in the world as well as routinely used ingredient in Chinese dishes and also in Chinese medicine (2). China is one of the largest producers of *Auricularia* (3). China Edible Fungi Association has been reported the annual production in 2017 reached nearly 75.2 and 16.9 million tons for *A. auricula* and *A. cornea*, respectively. *Auricularia* produce many types of polysaccharides (4) and these kinds of polysaccharides have the ability to stimulate the inner systems in human body that can stop proliferation of cancer cells (5). It has also been reported to have antitumor (6), antioxidant (7), anticoagulant (8),antibacterial, anti-parasitic (9,10),anti-inflammatory(11), immunomodulatory (12), prevention of alcohol-related liver diseases (13) and hypo glycemic (14) properties. Additionally, *Auricularia* has been reported to contain high level of crude protein, low level of fat and 60% of fatty acids are unsaturated (15) which contributes to treat cardiovascular, hypo cholesterol (16) and obesity (17)

Auricularia species contain more fiber (18). Hence, they have the ability to medicate constipation (19). *Auricularia cornea* var. *Li.* is a natural mutation strain of *A. cornea* and it has been favoured by customers for its white colour, flavour, and medicinal properties.

However, there are insufficient studies were carried out about nutritional composition of *A. cornea* var. *Li.*. Therefore, this study was conducted to determine the nutrition compositions and the mineral elements of *A. cornea* var. *Li*. expecting that this information could be used by academics, medicines, and consumption market.

A. cornea, A. cornea var. *Li.* on a decaying trunk in nature shown in Figure 1 and Figure 2 respectively. Artificially cultivated *A. cornea* var. *Li***.** shown in Figure 3.

Figure 1. *Auricularia cornea* in nature

Figure 2. Naturally mutation white strain *Auricularia cornea var. Li.* in nature.

Figure 3. Naturally mutation white strain *Auricularia cornea* var. *Li.* in nature.

Materials and methods

Spawn Preparation and Fruiting Body Production

Auricularia cornea var. *Li.* used in this study was provided by Beijing Engineering Research Center for Edible Mushrooms. The strain was cultured and maintained on potato dextrose broth at 25 °C. When required, 1.5% (w/v) agar was added to the appropriate medium. Eighty percentage of oak (*Quercus* spp) sawdust, 18% of wheat bran, and 2% of lime were used to prepare substrate and the water content of the substrate was adjusted to 62% (W/W). One kilogram of substrate was filled in polyethylene bags (16 cm × 32 cm × 0.04 cm) which were then, autoclaved at 121 °C for 120 min. Autoclaved substrate was inoculated with *A. cornea* var. *Li*. spawn by 2% (w/w) of substrate fresh weight. Inoculated polyethylene bags were kept in the spawn running room at 25 °C and 70% RH under dark condition. After the mycelium completely colonized, bags were unfolded in order to facilitate the fruiting body development and maintained at 25 °C and 85-90% RH. Fruiting bodies were harvested at mature stage.

General Chemical Analysis

Fresh mushrooms were collected randomly after the first flush and dried at 60 °C to a constant weight. Mushroom nutrition compositional analyze were carried out according to the AOAC (20) standard procedures for moisture, ash, crude protein, fat and fiber. Moisture content (%) was determined by drying 10.0

g of dried mushroom in oven. Crude protein (%) was analyzed using dried, ground mushrooms (1.0 g) by micro-Kjeldahl method; the nitrogen factor used for crude protein calculation was 6.25. The level of crude fat (%) was determined by Soxhlet extraction of dried mushrooms (3.0 g). Total dietary fiber (%) was determined by taking approx. 3.0 g dried mushroom with H_2SO_4 (1.25%) and NaOH (1.25%) followed by heating at 105 ± 5 °C in hot air oven up to the constant weight. Total ash (%) content was determined by burning dried mushrooms (3.0 g) in a muffle furnace at 55 °C for 8 hrs until ashing was completed. Total carbohydrates (%) were estimated by determining the difference as follow:

Total carbohydrates (%) = 100 – (% Moisture + % Crudeprotein+%Crudefat+%Totaldietaryfiber+%Ash) (Eq.1)

Total energy was calculated as in (21) formula:

Energy (kcal) = 4× (g Protein) + 9× (g Fat) +4× (g Carbohydrates) + 2 × (g Total dietary fiber) (Eq.2)

Mineral Elements Analyses

Five hundred milligrams of mushroom samples were burned to ash in a muffle furnace at 450 °C. Then residue was dissolved with 0.5 mL/mL of HNO_3, 0.5 mL/mL of HCl (20) and added proper amount of distilled water to which were directly weighed iron (Fe), copper (Cu), zinc (Zn), manganese (Mn). It was diluted by 25 ml of distilled water to measure the other elements (22). The concentrations of iron (Fe), copper (Cu), zinc (Zn), manganese (Mn), potassium (K), sodium (Na), calcium (Ca), and magnesium (Mg) were determined in an flame atomic absorption spectrometry in Analyst 200 Perkin Elmer equipment.(Perkin Elmer, Waltham, MA, USA).

After the crude fat extraction procedure, fatty acids were determined following the methods described in (23), by gas chromatography (DANI 1000) with split/splitless injector with flame ionization detection (GC-FID) (DANI Instrument SpA., Cologno Manzese, Italy). A high polar chromatography column HP-88 was used (100 m × 0.25 mm × 0.2 μm) (Agilent Technologies, CO, Santa Clara, USA). Hydrogen flow rate was 4.mL/min. Split injection was carried out at 250 °C (1:40). Relative percentage of each fatty acid was expressed by FAME mixture with standard. The amino acid composition was determined by a high performance liquid chromatograph (HPLC)-based amino acid analyzer (Agilent 1120 Compact LC) as detailed in (24), Vitamin-E was determined via spectrophotometry detailed in (25).

Statistical Analysis

Three replicates of *A. cornea* var. *Li.* samples were used for all the analyses. Nutrition compositional values were calculated as the mean ± S.E of three independent determinants on dry weight basis.

Results

Chemical compositions of analyzed *A. cornea* var. *Li.* are shown in Table 1. All the values were calculated based on their composition in 100 g of dry matter. The *A. cornea* var. *Li*. has been recorded to contain 219.89 Kcal of energetic value, 2.74 g of moisture, and 2.43 g of ash. Total dietary fiber was the dominant compound and it showed 78.94 g, followed by protein (8.68 g), carbohydrates (6.31 g), and ash (2.43 g). Fat showed the lowest value and recorded 0.91 g.

The mineral contents of the *A. cornea* var. *Li* obtained from the experiment are given in the Table 2. The macro element potassium was the most abundant among all and recorded 1121.66 mg, followed by magnesium (143.23 mg), calcium (108.97 mg) and finally Sodium (29.22 mg) in sample. Among microelements, zinc was the most abundant and it recorded as 10.13 mg, followed by iron (3.82 mg), copper (1.41 mg) and manganese (0.50mg) in *A.cornea* var. *Li.*. The vitamin E was also recorded as 0.59 mg.

Table 1. Chemical compositions of *A.cornea* var. *Li.*

Chemical component (per 100 g)	Value
Energetic value (kcal)	219.89±1.19
Total dietary fiber (g)	78.94±0.64
Protein (g)	8.68 ±0.03
Carbohydrates (g)	6.31±0.54
Ash (g)	2.43±0.04
Moisture (g)	2.74± 0.05
Fat (g)	0.91±0.02

Values are expressed as the mean ± S.E of three independent determinations on dry weight basis.

Table 2. Mineral content of *A.cornea var. Li.*

Mineral content (mg/100g)	Value
Sodium	29.22± 0.77
Vitamin E	0.59±0.00
Potassium	1121.66± 30.53
Magnesium	143.23±2.16
Calcium	108.97±0.94
Iron	3.82±0.13
Zinc	10.13±0.31
Copper	1.41±0.03
Manganese	0.50±0.00

Values are expressed as the mean ± S.E of three independent determinations on dry weight basis.

Free amino acid of the mushroom studied is shown in Table 3. Eighteen amino acids were identified in *A. cornea* var. *Li*. Glutamic acid showed more than 13% of the total detected amino acid content and it was recorded 0.87 g. Aspartic acid recorded as 0.76 g. The lowest value was noted in methionine and it was 0.03 g.

Table 3. Amino acid profile of *A. cornea var. Li.*

Detected free Amino acids content (g/100g)	*A .cornea* var. *Li.*	Percentage of Amino acids content
Aspartic acid (ASP)	0.76±0.007	11.74
Threonine (THR)	0.41±0.009	6.33
Serine (SER)	0.41±0.006	6.34
Glutamic acid (GLU)	0.87±0.006	13.48
Glycine (GLY)	0.34±0.006	5.19
Alanine (ALA)	0.52±0.003	8.09
Valine(VAL)	0.37±0.004	5.70
Methionine (MET)	0.03±0.002	0.40
Isoleucine (ILE)	0.20±0.007	3.09
Leucine (LEU)	0.53±0.008	8.15
Tyrosine (TYR)	0.20±0.009	3.03
Phenylalanine (PHE)	0.33±0.013	5.03
Lysine (LYS)	0.41±0.007	6.32
Histidine (HIS)	0.16±0.003	2.43
Arginine (ARG)	0.39 ±0.004	5.96
Proline (PRO)	0.36±0.007	5.48
Tryptophan(TRP)	0.12±0.002	1.82
Cysteine (CYS)	0.09±0.002	1.43

Values are expressed as the mean ± S.E of three independent determinations on dry weight basis

Fatty acid and their percentage of detection in *A. cornea* var. *Li* presented in Table 4. Linoleic was predominating over the other fatty acids constituents and recorded as 0.36 g. Linoleic acid showed more than 43% of total fatty acid content in *A. cornea* var. *Li*. Considerable amount of *cis*-9-octadecenoic acid and palmitic acid were observed and values recorded as 0.25 g and 0.11 g, respectively. Other fatty acids, such as myristic acid, pentadecanoic acid, hexadecanoic acid, octadecanoic acid and behenic acid were found in minor amounts.

Table 5 shows the previous studies records of white strains in *Auricularia* spp.

Free amino acid of the *A. cornea var. Li*, *A. polyticha* and *A. fuscosuccinea* were compared with the current study and previous records and presented in the Table 6.

Table 4. Fatty acid profile of *A. cornea var. Li.*

Detected fatty acids (g/100g)	Number of carbon	*A. cornea* var. *Li.*	Percentage of Fatty acid content
Myristic acid	C14:0	0.01±0.002	0.94
pentadecanoic acid	C15:0	0.02 ±0.000	2.42
palmitic acid	C16:0	0.11±0.000	13.25
stearic acid	C18:0	0.06±0.005	7.83
cis-9-octadecenoic acid	C18:1n9c	0.25 ±0.012	29.83
linoleic acid	C18:2n6c	0.36±0.001	43.54
αlinolenic acid	C18:3n3	0.01±0.003	1.52
behenic acid	C22:0	0.01±0.001	1.14

Values are expressed as the mean ± S.E of three independent determinations on dry weight basis.

Table 5. Previous studies of white strains recorded in *Auricularia* spp.

White strains of *Auricularia* spp.	Ash (g/100g)	Protein (g/100g)	Total dietary Fiber (g/100g)	Fat (g/100g)
A. polyticha (26)	2.49	12.33	24.82	-
A. polyticha (27)	2.1	7.7	-	0.45
A. fuscosuccinea (28)	5.5	17.83*	-	4.5
A. cornea var. *Li.* (our study)	2.43	8.68	78.94	0.91

** means the nitrogen factor used for crude protein calculation was 6.25, replaced the original factor 4.38.*

Table 6. Free amino acid contents of *A. cornea var. Li.* , *A. polyticha* and *A. fuscosuccinea*.

Detected free Amino acids (g/100g)	*A .cornea* var. *Li.* (our study)	*A. polyticha* (26)	*A. fuscosuccinea* (28)
Aspartic acid (ASP)	0.76±0.007	1.12	0.06
Threonine (THR)	0.41±0.009	0.63	0.16
Serine (SER)	0.41±0.006	0.57	0.16
Glutamic acid (GLU)	0.87±0.006	1.28	0.16
Glycine (GLY)	0.34±0.006	0.52	0.02
Alanine (ALA)	0.52±0.003	0.80	0.04
Valine(VAL)	0.37±0.004	0.62	0.03
Methionine (MET)	0.03±0.002	0.64	-
Isoleucine (ILE)	0.20±0.007	0.43	0.03
Leucine (LEU)	0.53±0.008	0.84	-
Tyrosine (TYR)	0.20±0.009	0.33	0.06
Phenylalanine (PHE)	0.33±0.013	0.57	0.02
Lysine (LYS)	0.41±0.007	0.61	-
Histidine (HIS)	0.16±0.003	0.26	-
Arginine (ARG)	0.39 ±0.004	0.67	0.08
Proline (PRO)	0.36±0.007	0.55	-
Tryptophan(TRP)	0.12±0.002	0.13	0.01
Cysteine (CYS)	0.09±0.002	0.07	-

Discussion

The *A. cornea* var. *Li*. white strain is enormously preferred by consumers in China for their white colour and flavour with their nutritional and pharmaceutical characters. As in (29), the chemical composition of edible mushrooms defines their nutritional value and sensory properties. Therefore, its timely needed to analyze the nutritional compositions of *A. cornea* var. *Li.* which have the benefits of making healthy food decisions and maintaining healthy weights for consumers, food production industries, medicines, and research based fields.

The nutrition compositions of mushroom are easily influenced by the growing substrate and environment (30,31,32,33). In our study, Oak sawdust was used as the main substrate. The nutrient values of mushroom can be different regarding to their substrate.

The *A. polyticha* (26, 27) (Table 5) shown more similar amounts of ash content with *A. cornea* var. *Li.*, although *A. fuscosuccinea* (28) contain it fairly high. *Auricularia* species generally rich in fiber than other cultivated mushroom species such as *Agaricus bisporus, Tremella fuciformis* (19). According to (2), more than 50% of fiber content has been reported in *A. auricula-judae*. Total dietary fiber of this study showed (78.94 ± 0.64 g) higher value than *A. polyticha* (26) (24.82 g) (Table 5). *Auricularia* species produce two kinds of αD-glucans, acidic hetero types polysaccharides (4), *A. cornea* var. *Li.* also has been reported to contain several types of polysaccharides (13) and these non-starchy polysaccharides could be a higher source of dietary fiber which was observed in *A. cornea* var. *Li.*.

Fiber is often mentioning to as the seventh nutrient and mainly consists of cellulose, hemicellulose, and lignin (34). They have the ability to promote intestinal absorption and digestion, medicate constipation (19), lowering blood sugar, prevents circulatory and intestinal cancer (35). Therefore, intake of *A. cornea* var. *Li.* with high level of fiber has great impacts on healthy diets.

Our study indicates that, protein value of *A. cornea* var. *Li*. was slightly higher than *A. polyticha* (27), while it's slightly lower than *A. polyticha* (26) and deviated from *A. fuscosuccinea* (28) (Table 5). *A. cornea* var. *Li.* showed the values in between values among the white strains. Eighteen amino acids were identified in this study. All the detected amino acids of *A. cornea* var. *Li.* values were higher than *A. fuscosuccinea* (28). Compositions of amino acid was consistent with the previous study of *A. polyticha* (26) with some quantity differences. As reported in (36,37) about edible mushrooms, *A. cornea* var. *Li.* is also especially rich in glutamic acid (0.87 g) and considerable amount of aspartic acid (0.76 g). Glutamic acid recorded more than 13% of the total detected amino acid contents. It is well known the glutamic acid contribute to the flavour properties of mushroom (38) could be associated with desires flavour of *A. cornea* var. *Li.*. Sulphur-containing amino acids are typically lacking in mushrooms (39,40). The *A. cornea* var. *Li*. found to be a good source of protein with includes all of the nine essential amino acids among the other white strains of *Auricularia.*

In our study, *A. cornea* var. *Li.* contains lower fat value (0.91 g) than *A. fuscosuccinea* (4.5 g) (28) and higher value than *A. polyticha* (27) (0.45 g) (Table 3). Mushrooms are low in fat which have been recom-

mended as ideal vegetable for the fatness (30). Hence, *A. cornea* var. *Li* has low fat value, is advisable for treating cardiovascular, hypo cholesterol and obesity related diseases. Linoleic acid recorded more than 43% of total detected fatty acids. Linoleic acid is an essential fatty acid to mammals; therefore, could be supplied by *A. cornea var. Li.*. Unsaturated fatty acids are probable forerunner flavour compound source in fungi, these fatty acids are the precursor of 1-*octen*-3-*ol,* recognized as the alcohol of fungi, which is the primary aromatic compound in most fungi (38). Hence, the linoleic acid in *A. cornea* var. *Li.* could be narrowly related to their preferred flavour.

A. cornea var. Li. analyzed in the present study appeared to be rich in minerals; especially, potassium, magnesium, calcium, sodium, zinc and iron (Table 2). Minerals are necessary for metabolic reactions, ruling of water and ions balance, strong bone formation which relates with calcium, coordination of nerve impulses particularly sodium, helping to control blood pressure and maintain muscle and nerve functions specially potassium (41) and supports curing iron-deficiency anemia conditions by iron (42, 43).

Conclusion

A. cornea var. *Li* was found to be a rich sources of dietary fiber, proteins, minerals with having low fat value. Even though consumers prefer the flavour, taste and medicinal properties, they have enriched with nutritional contents which making them in well-balanced diets.

Acknowledgement

This work was supported by Beijing Agriculture Innovation Consortium (BAIC05-2019), the Open Research Fund Program of Beijing Key Lab of Plant Resource Research and Development, Beijing Technology and Business University (PRRD-2019-YB3).

Conflict of interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Harding & Patric. Mushroom Miscellany 2008; 1st edn: London, Harper Collins Publisher. ISBN: 100007284640.
2. Sekara A, Kalisz A, Grabowska A, Siwulski M. *Auricularia* spp.—mushrooms as novel food and therapeutic agents—a review. Sydowia 2015; 67: 1–10.
3. Zhang Y, Geng W, Shen Y, Wang Y, Dai YC. Edible mushroom cultivation for food security and rural development in China: bio-innovation, technological dissemination and marketing. Sustainability 2014; 6(5): 2961–2973.
4. Sone Y, Kakuta M, Misaki A. Isolation and characterisation of polysaccharides of "Kikurage," fruit body of *Auricularia auricula-judae.* Agricultural and Biological Chemistry 1978; 42**:** 417-425.
5. Wasser SP, Weis AL. Therapeutic effects of substances occurring in higher basidiomycetes mushrooms: A modern perspective. Critical Reviews in Immunology 1999; 19: 65-96.
6. Wang J, Li X, Song G. An efficient separation method of polysaccharides: preparation of an antitumor polysaccharide APS-2 from *Auricularia polytricha* by radial flow chromatography. Chromatographia 2013;19:629-33.
7. Elisashvili V. Submerged cultivation of medicinal mushrooms: bioprocesses and products (review). International Journal of Medecinal Mushrooms 2012; 14(3): 211–239.
8. Chen G, Luo YC, Ji BP, Li B, Su W, Xiao ZL, Zhang GZ. Hypo cholesterolemic effects of *Auricularia auricula* ethanol extract in ICR mice fed a cholesterol-enriched diet. Food Science and Technology 2011; 48(6): 692–698.
9. Yu M, Xu X, Qing Y, Luo X, Yang Z, Zheng L. Isolation of an anti-tomor polysaccharide from *Auricularia polytricha* (jew's ear) and its effects on macrophage activation. European Food Research and Technology 2009; 228: 447-485.
10. Song G, Du Q. Structure characterization and antitumor activity of an α β-glucan polysaccharide from *Auricularia polytricha*. Food Research International 2012; 45:381-387.
11. Damte D, Reza MA, Lee SJ, Jo WS, Park SC. Anti-inflammatory activity of dichloromethane extract of *Auricularia auricula-judaein* RAW264.7cells. Toxicol Research 2011; 27(1): 11–14.
12. Sheu F, Chien PJ, Chien AL, Chen YF, Chin KL. Isolation and characterization of an immunomodulatory protein (APP) from the Jew's Ear mushroom *Auricularia polytricha*. Food Chemistry 2004; 87(4): 593–600.
13. Wang X, Lan Y, Zhu Y, et al. Hepatoprotective effects of *Auricularia cornea* var. *Li.* polysaccharides against the alcoholic liver diseases through different metabolic pathways. Scientific Reports 2018; *8*:7574.
14. Wu NJ, Chiou FJ, Weng YM, Yu ZR. In vitro hypoglycemic effects of hot water extract from (wood ear mushroom). International Journal of Food Science and Nutrition 2014; 65: 502-6.
15. Kavishree S, Hemavathy J, Lokesh BR, Shashirekha MN, Rajarathnam S. Fat and fatty acids of Indian edible mushrooms. Food Chemistry 2008;106(2):597–602.
16. Zhao S, Rong C, Liu Y, Xu F. Extraction of a soluble poly-

saccharide from *Auricularia polytricha* and evaluation of its anti-hyper cholesterolemic effect in rats. Carbohydrate Polymers 2015; 122: 39-45.
17. Reza MA, Hossain MA, Damte D, Jo WS, Hsu WH, Park SC. Hypolipidemic and hepatic steatosis preventing activities of the wood ear medicinal mushroom *Auricularia auricula-judae* (higher Basidiomycetes) ethanol extract in vivo and in vitro. International Journal of Medecinal Mushrooms, 2015; 17(8): 723–734.
18. Cheung PCK. Dietary fiber content and composition of some edible fungi determined by two methods of analysis. Science of Food and Agriculture 1997; 73(2): 255–260.
19. Kim TI, Park SJ, Choi CH, Lee SK, Kim WH. Effect of ear mushroom (*Auricularia*) on functional constipation. Korean Journal of Gastroenterol 2004*;* 44(1):34–41.
20. Association of Official Analytical Chemists (AOAC). Official methods of analysis of the Association of Official Analytical Chemists AOAC, 1995; 16th edn: Arlington,USA. ISBN: 0935584544.
21. Manzi P, Marconi S, Aguzzi A, Pizzoferrato L. Commercial mushrooms: nutritional quality and effects of cooking. Food chemistry 2004;84:201-206.
22. Ruiz-Rodriguez B, Morales P, Fernandez-Ruzi V, et al. Valorization of wild strawberry tree fruits (*Arbutus unedo* L.) through nutritional assessment and natural production data. Food Research International 2011; 44: 1244-1253.
23. Barreira JCM, Antonio AL, Gunaydi T, et al. Chemometric characterization of gamma irradiated chestnuts from Turkey. Radiation Physics and Chemistry 2012; 81: 1520-1524.
24. Partil SS, Ahmed SA, Telang SM, Baig MMV. The nutritional value of *pleurotus ostreatus* (JACQ.:FR.) Kumm cultivated on different lignocellulosic agro wastes. Innovative Romanian Food Biotechnology 2010;7:66-76.
25. Rishi L, Jadoon S, Waseem A, Yaqoob M, Nabi A. Flow injection methods for the determination of α-tocopherol with spectrophotometric detection. Chemical Society of Pakistan, 2011; 33(4): 508–514.
26. Yao Q, Chen G, Yan S, Lin X, Lin Q. 两种木耳营养分析与评价(Nutritional analysis and evaluation of two varieties of *Auricularia polytricha*). Acta Nutrimenta Sinica 2018; 40(2): 197-199. DOI: 10.13325/j.cnki.acta.nutr.sin.2018.02.023.
27. Zhang X, Jia J, Zhang AG, Li C, Zhou L. 玉木耳新品与传统黑木耳营养成分检测及分析研究(Nutritional detection and analysis of white *Auricularia polytricha* and *A. auricular)*. China Food Safety Magazine 2017; 10: 97-97. DOI:10.16043/j.cnki.cfs.2017.30.073.
28. Mau JL, Wu KT, Wu YH, Lin YP. Nonvolatile taste components of ear mushrooms. Agricultural Food Chemistry 1998; 46(11): 4583–4586.
29. Manzi P, Aguzzi A, Pizzoferrato L. Nutritional value of mushrooms widely consumed in Italy. Food Chemistry 2001; 73: 321-325.
30. Kurtzman RH. A review mushrooms: sources for modern western medicine. Micologia Aplicada International 2005; 17: 21–33.
31. Gregori A, vagelj M, Pohleven J. Cultivation techniques and medicinal properties of Pleurotus spp. Food Technology and Biotechnology 2007; 45: 238–249.
32. Wang D, Sakoda A, Suzuki M. Biological efficiency and nutritional value of *Pleurotus ostreatus* cultivated on spent beet grain. Bioresources technology 2001; 78: 293-300.
33. Ahmed SA, Kadam JA, Mane VP, Patil SS, Baig MMV. Biological efficiency and nutritional contents of *Pleurotus* florida (Mont.) singer cultivated on different agro-wastes. Nature and Science 2009; 7: 44–48.
34. Anita FP, Abraham P. Clinical dietetics and nutrition 1997; 4th edn: Calcutta, Delhi Oxford University Press. IBSN: 0192641565.
35. Cheung PCK. Mini-review on edible mushrooms as source of dietary fiber: preparation and health benefits. Food Science and Human Wellness 2013;2(3–4):162–166.
36. Kim MY, Chung MI, Lee SJ, et al. Comparison of free amino acid, carbohydrate concentrations in Korean edible and medicinal mushrooms. Food Chemistry 2009; 113: 386 – 393.
37. Madachi SJM, Nkunya MHH, Nyigo VA, Urasa IT. Amino acid composition of some Tanzanian wild mushrooms. Food Chemistry 2004;86:179-182.
38. Maga JA. Mushroom flavour. Agricultural Food Chemistry 1981; 29(1): 1–4.
39. Senatore F, Dini A, Marino A. Chemical constituents of some basidiomycetes. Science of Food and Agriculture 1988; 45: 337–345.
40. Senatore F. Fatty acid and free amino acid content of some mushrooms. Science of Food and Agriculture 1990; 51: 91–96.
41. Kalac P, Svoboda L. A review of trace element concentrations in edible mushrooms. Food Chemistry 2000; 69: 273- 281.
42. Anderson GJ, Frazer DM, McLaren GD. Iron absorption and metabolism. Curr Opin Gastroenterol 2009; 25: 129–135.
43. Byrnes V, Barrett S, Ryan E, et al. Increased duodenal DMT-1 expression and unchanged HFE mRNA levels in HFE-associated hereditary hemochromatosis and iron deficiency. Blood Cells, Molecules & Diseases 2002; 29: 251–260.

Correspondence:
Shouxian Wang
Institute of Plant and Environment Protection, Beijing Academy of Agriculture and Forestry Sciences
Beijing, 100097, China.
E-mail: wangshouxian2002@163.com

Wasantha K.L
Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Sri Lanka .
E.mail: wasanthk2011@gmail.com