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Review

A mini-review of chemical composition and nutritional value of edible wild-grown mushroom from China

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ABSTRACT

In China, many species of edible wild-grown mushrooms are appreciated as food and also found use in traditional Chinese medicine. In this mini-review, for the first time, is summarized and discussed data available on chemical components of nutritional significance for wild-grown mushrooms collected from China. We aimed to update and discuss the latest data published on ash, fat, carbohydrates, fibre, proteins, essential amino acids and nonessential amino acids, some essential (P, K, Na, Ca, Mg, Fe, Mn, Zn, Cu) and toxic elements (As, Hg, Cd, Pb), vitamins (thiamine, riboflavin, niacin, tocopherol, vitamin D), flavour and taste compounds, antioxidants and also on less studied organic compounds (lectin, adustin, ribonuclease and nicotine) contents of wild-grown mushrooms.

Contents

1. Introduction

The majority of mushrooms widely collected in China are the macrofungi forming basidiomycetes, and only a few are of the ascomycete group (Zhang et al., 2006). For some regions of China, the rate of mushroom consumption is relatively high, e.g., up to 20–24 kg fresh product per capita annually, which is a

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substantially higher figure than for people from many other countries (Zhang et al., 2010). Edible wild-grown mushrooms are collected at all continents worldwide because they are traditionally recognised as valued sources of nutrients (Kalač, 2013; Nnorom et al., 2013; Zheng, Suwandi, Fuller, Doromla, & Ng, 2012). Apart from flavour and taste, the fruiting bodies of mushrooms are considered sources of organic nutrients such as digestible proteins, carbohydrates, fibre and certain vitamins, as well as minerals and antioxidants (Nnorom et al., 2012; Pereira, Barros, Martins, & Ferreira, 2012; Szubstarska, Jarzyńska, & Falandysz, 2012).

In China, Yunnan province, with an area of 390,000 km^2 and elevation of 76.4–6740 m, is a specific region abundant in wild-grown mushrooms and over 880 species are identified as edible, which accounts for 80% of the edible species identified in China and around 40% in the world (Wu, Luo, Liu, & Gui, 2010). China also exports edible wild-grown mushrooms. For example, in 2010 and 2011 the export rate of Yunnan was 105,000 and 135,000 tonnes, respectively (Zhang and Yang, 2013). *Tricholoma matsutake* is the most valuable wild-grown mushroom in China and the export rate of this species from Yunnan accounts for more than 80% of the total export from China (Wu et al., 2010).

Mushrooms can be cooked in several ways and this can have an impact on the nutrients and other compounds in the meal (Falandysz and Borovička, 2013). China has its own traditional method of cooking called "urgent fire stir fry". Using this traditional way of cooking, it is possible to preserve vitamin B_2 and a collection of minerals completely (Zhou and Yin, 2008). This is as sliced fresh mushrooms are cooked using a wok (a Chinese pan) with boiling vegetable oil and some additional ingredients (green onion, ginger, garlic, pepper, salt, mono-sodium glutamate, soy, etc.) for about 5 min. In this way, there is no loss of any constituent of a mushroom meal. China also employs other ways to cook mushrooms (frying, baking, boiling etc.), but they used relatively infrequently, while sliced *Tricholoma matsutake* is even eaten raw.

The number of reports on nutrients and antinutrients (As, Hg, Cd, Pb etc.) of uncooked mushrooms has grown recently (Akata, Ergonul, & Kalyoncu, 2012; Gucia et al., 2012; Liu, Li, & Tang, 2012; Zhang, Yang, & Ma, 2011; Zhang et al. 2013; Falandysz, Kawano, Świeczkowski, Brzostowski, & Dadej, 2003; Falandysz, Jarzyńska et al., 2012; Falandysz, Widzicka et al.,2012; Guo et al., 2012). Nevertheless, due to a large number of species growing worldwide and various cooking methods and recipes, our knowledge on the nutrient composition and value of mushrooms is still limited (Falandysz and Borovička, 2013). Another difficult problem is the quality of analytical data published on the chemical composition of mushrooms, a good example being a discussion on the quality of data published on mushroom mineral constituents (Falandysz, 2012, 2013; Jarzyńska and Falandysz, 2011a).

2. Dry matter, proximate composition and energy value

Dry matter content of fresh mushrooms is relatively low, i.e. around 10%, and is mainly composed of carbohydrates, proteins, fibre and minerals (Table 1). When considering the chemical composition of mushrooms, it is worthwhile to keep in mind that water content is the parameter that is to some degree, variable for "fresh" mushroom. This is because changing weather conditions can to some degree influence the moisture content of collected fruiting bodies (mushrooms). Fruiting bodies, after collection, also lose moisture easily due to evaporation. There is a consensus that the moisture content of fresh fruiting bodies is 90%, and data published on the chemical composition of mushrooms needs to be normalised to dry matter contents (Chudzyński and Falandysz, 2008).

Accordingly, proximate composition of mushrooms also varies within and among species, and fruiting body maturity can also play a role. This is well illustrated by large sets of data available recently on certain minerals in the flesh of several species of edible mushrooms (Chudzyński, Jarzyńska, Stefańska, & Falandysz, 2011; Falandysz, Mazur et al., 2012; Li, Wang, Zhang, Zhao, & Liu, 2011; Melgar, Alonso, & García, 2009; Aloupi, Koutrotsios, Koulousaris, & Kalogeropoulos, 2012). Environmental factors can have an impact on the abundance of certain compounds in mushrooms, but the reason(s) for the variations in the composition of mushroom species collected from background areas remains unclear (Falandysz and Bielawski, 2007; Jarzyńska, Chojnacka, Dryżałowska, Nnorom, & Falandysz, 2012). Another source of variation in the composition and nutritional value of mushrooms is time variation as noted for certain mineral elements in a few species (Brzostowski, Jarzynska, Kojta, Wydmanska, & Falandysz, 2011; Gucia, Jarzyńska, Kojta, & Falandysz, 2012). As such certain types of variations impact the nutritional value of mushrooms and as such, more research on different constituents of edible mushrooms is desirable.

The species listed in Table 1 are mushrooms that are high in carbohydrates, crude protein and fibre and comparatively less abundant in minerals and crude fat. In a report by Liu and co-workers (2012), energy values of five wild-grown species of mushrooms varied between 15164 kJ kg^{-1} dm for *Catathelasma ventricosum* and 17366 kJ kg^{-1} dm for *Clitocybe maxima.*

3. Carbohydrate and fibre

Carbohydrates in foods provide energy and digestible carbohydrates found in mushrooms are such as mannitol (0.3–5.5% dm) (Vaz et al., 2011), glucose (0.5–3.6% dm) (Kim et al., 2009) and glycogen (1.0–1.6% dm) (Díez & Alvarez, 2001). Non-digestible carbohydrates form a large portion of the total carbohydrates of mushrooms, and major compounds are oligosaccharides and

Table 1
Proximate composition of some edible wild-grown mushrooms of China (*mean* values; % of dry matter).

Species	Number of samples (*n*)	Carbohydrates	Crude fibre	Crude protein	Crude fat	Ash	References
B. aereus	1	34.0	17.0	26.9	2.1	8.5	Zhou and Yin (2008)
B. edulis	1	30.6	15.3	28.7	4.1	9.2	Zhou and Yin (2008)
B. speciosus	1	28.6	21.0	28.1	2.9	7.6	Zhou and Yin (2008)
C. aureus	1	61.5	5.2	14.1	4.0	9.2	Zhang and Chen (2012a)
Lactarius deliciosus	1	25.0	36.3	20.2	2.5	7.5	Yin and Zhou (2008)
Lactarius hatsudake	1	38.2	31.8	15.3	1.0	7.3	Yin and Zhou (2008)
Lactarius volemus	1	15.0	40.0	17.6	6.7	13.3	Yin and Zhou (2008)
L. crocipodium	1	12.8	37.9	29.3	1.0	5.8	Zhou and Yin (2008)
Lentinula edodes	1	30.2	39.4	17.1	1.9	4.3	Zhu et al. (2007)
R. virescens	1	13.4	32.8	28.3	1.5	11.9	Yin and Zhou (2008)
S. aspratus	1	64.6	5.1	12.0	2.8	10.4	Zhang and Chen (2011)
T. matsutake	3	36.7	29.1	14.3	5.0	8.9	Liu et al. (2010)