Journal of Food Composition and Analysis 41 (2015) 165–173

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

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

Critical Review

Beta-glucans from edible and medicinal mushrooms: Characteristics, physicochemical and biological activities

Fengmei Zhu[a,1], Bin Du[a,b,c,1], Zhaoxiang Bian[b], Baojun Xu[c,*]

[a] Hebei Normal University of Science and Technology, Qinhuangdao, Hebei 066600, China
[b] School of Chinese Medicine, Hong Kong Baptist University, Hong Kong, China
[c] Food Science and Technology Program, Beijing Normal University–Hong Kong Baptist University United International College, Zhuhai, Guangdong 519085, China

ARTICLE INFO

Article history:
Received 15 June 2014
Received in revised form 12 January 2015
Accepted 22 January 2015
Available online 5 March 2015

Chemical compounds studied in this article:
Beta-glucan (PubChem CID: 136779747), Hydrochloric acid (PubChem CID: 24845468), Sodium hydroxide (PubChem CID: 24845831), Potassium hydroxide (PubChem CID: 24844923), Congo red (PubChem CID: 11313)

Keywords:
Mushroom, β-Glucan, Structure, Extraction, Quantification, Bioactivity, Food analysis, Food composition

ABSTRACT

One of the main active components from mushrooms was recently identified as β-glucan. Health-promoting β-glucans are an auspicious group of polysaccharides. β-Glucans from different sources such as cereals, yeast and grass have previously been documented. However, information on mushroom β-glucan is limited. This review summarizes the extraction, purification, quantification, and structural characterization of β-glucans, along with chemical and biological activities from this compound from mushrooms, and the current status of this research area with a view for future directions.

Contents

* Corresponding author at: 28, Jinfeng Road, Tangjiawan, Zhuhai, Guangdong 519085, China. Tel.: +86 756 3620636; fax: +86 756 3620882.
E-mail address: baojunxu@uic.edu.hk (B. Xu).
[1] These authors contributed equally to this work.

http://dx.doi.org/10.1016/j.jfca.2015.01.019
0889-1575/

1. Introduction

Mushroom is the spore-bearing fruiting body of a fungus, typically produced above ground on soil. Fresh and preserved mushrooms are consumed in many countries as a delicacy, particularly for their specific aroma and texture (Kalac, 2013). It is well-known that mushrooms contain a very large variety of biomolecules with nutritional (Kalac, 2009) and medicinal properties (Borchers et al., 2004; Lindequist et al., 2005; Poucheret et al., 2006). Due to these properties, mushrooms have been recognized as natural sources for the development of medicines and nutraceuticals (Alves et al., 2012).

Mushrooms are also recognized as functional foods for their bioactive compounds that offer diverse beneficial impacts on human health. One such potent component is β-glucan (Ren et al., 2012). Most β-glucans are derived from the fruiting bodies of mushrooms. β-Glucans are polysaccharides of D-glucose monomers linked by β-glycosidic bonds. It is a kind of dietary fibre in cereals, yeasts, mushrooms, some bacteria and seaweeds (Du et al., 2013). β-Glucan from mushrooms consists of β-(1 → 3) and (1 → 6) linkages (Fig. 1) (Laroche and Michaud, 2007). β-Glucans from various sources have different branching pattern, linkage type and molecular weight (MW). β-Glucans from mushroom comprise a backbone of glucose residues linked by β-(1 → 3)-glycosidic bonds with attached β-(1 → 6) branch points, which exhibits antitumour and immune-stimulating properties. Mushroom-originated β-glucan seems to show very different activities from β-glucan derived from oat and barley. Mushroom β-glucan has shown effectiveness as an anti-tumour defense and as an immune system booster. β-Glucan from oats and barley help in lowering cholesterol and blood sugar. The primary structure, solubility, degree of branching (DB), MW, charge of polymers, and structure in aqueous media, all affect biological activities of β-glucan (Zekovic et al., 2005).

Review papers about β-glucan from different sources, such as cereals, yeast, and grass, have been published (Buckeridge et al., 2004; Brennan and Cleary, 2005; Lazaridou and Biliaderis, 2007; Wood, 2007; Petravic-Tominac et al., 2010; Havrlentová et al., 2011; Daou and Zhang, 2012; Rieder and Samuelsen, 2012). However, the review of mushroom β-glucan has received little attention. Thus, the main objective of this review is to address recent research findings on sources, structural features, viscosity and molecular weight, extraction, purification, and detection methods of β-glucan from edible and medicinal mushrooms. The biological properties of β-glucan from edible and medicinal mushrooms have also been included in this contribution.

2. Occurrence of β-glucan in mushroom

Mushrooms major cultivated species also contain relatively large amounts of carbohydrate and fibre, ranging from 51% to 88% and from 4% to 20% (dry weight basis) (Mattila et al., 2000). Shiitake (*Lentinus edodes*) and some members of the genus Oyster (*Pleurotus* spp.) are acknowledged to be some of the most important sources of β-glucans (Rop et al., 2009). Lentinan from the fruiting body of shiitake is a representative mushroom (1 → 3)-β-glucan with effective antitumour and immunopotentiating activity. Its primary structure is a (1 → 3)-β-glucan consisting of five (1 → 3)-β-glucose residues in a linear linkage and two (1 → 6)-β-glucopyranoside branches in side chains which result in a right-handed triple helical structure (Chihara, 2001). Another highly potent antitumour polysaccharide, schizophyllan from mushroom *Schizophyllum commune* is also a (1 → 3)-β-glucan having a β-glucopyranosyl group linked 1 → 6 to every third or fourth residue of the main chain. It is similar to lentinan in its triple helix structure and biological activities, but physico-chemically differs from lentinan. β-Glucans are also present in many other mushrooms, such as *Ganoderma lucidum*, *Grifola frondosa*, *Pleurotus abalones*, *Flammulina velutiper* and *Auricularia auricula*. A survey of the most important biologically active glucan and of the mushrooms in which they occur is presented in Table 1.

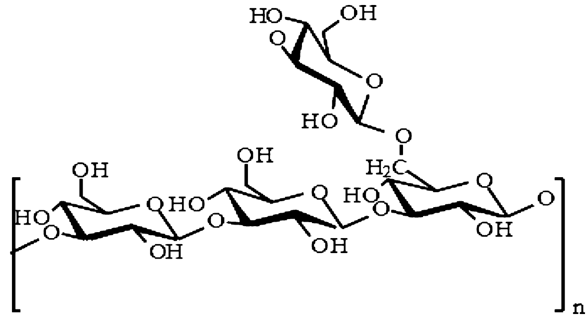

Fig. 1. Structure of (1 → 3) β-glucans with ramifications β (1 → 6). Copyright 2007 Recent Patents on Biotechnology. (Laroche and Michaud, 2007. New developments and prospective applications for β-(1,3) glucans. (Recent Patents on Biotechnology 1: 59–73).

3. Extraction and production of mushroom β-glucan

Extraction of β-glucan is a difficult job and requires special attention to produce consistent raw material (Ahmad et al., 2012). The nature of extraction procedure has a profound effect on the MW of β-glucan, which in turn affects its functional behaviour (Brennan and Cleary, 2005). The extraction methodologies are based on the solubility of β-glucan in hot water and in alkaline solutions. Separation of the dissolved proteins by isoelectric precipitation, and precipitation of the β-glucan by ammonium sulphate, 2-propanol, or ethanol are general ways. Kim et al. (2005) used distilled water (100 °C) at a ratio of 1:10 (w/v) to extract β-glucan from *Agaricus blazei* with extraction time 3 h. They reported that β-glucan showed anti-hyperglycaemic, anti-hypertriglyceridemic, anti-hypercholesterolemic, and anti-arteriosclerotic activities, thus indicating anti-diabetic activity as a whole in diabetic rats. Kumari et al. (2008) determined optimal operating conditions using one factor at a time method and response surface method to maximize production of schizophyllan by *S. commune* from an initial value of 1.06 g L^{-1} to 8.06 g L^{-1}. The fermentation was carried out for 168 h at 28 ± 2 °C on an orbital shaker at 180 rpm. Moreover, Kao et al. (2012) had successfully isolated low-molecular-weight β-1,3-glucan, in high yields, from the waste residue of extracted fruiting bodies of *G. lucidum*. They examined the polysaccharide from the residues of alkaline-extracted fruiting bodies using high-performance anion-exchange chromatography. The extraction techniques of polysaccharides (including β-glucan) have been summarized in a latest report of Villares et al. (2012).

4. Characteristics of mushroom β-glucans

4.1. Structural features of mushroom β-glucan

β-Glucans are cell wall components of mycete. Structural diversity of fungal (including mushrooms) glucans has been reviewed in a recent report (Synytsya and Novak, 2013). Structurally, mushroom β-glucans consist of linear β-(1 → 3)-linked backbones with β-(1 → 6)-linked side chains of varying