Will the sulphur polypore (laetiporus sulphureus) become a new functional food?

Introduction

The sulphur shelf (Laetiporus sulphureus Bull.:Fr.) Murrill., also known as crab-of-the-woods or chicken-of-the-woods, is a saprophyte mushroom from the family Polyporaceae that grow on trees in Europe, Asia and North America. Its fruit bodies have a striking golden-yellow color and grow on tree trunks and branches (Figure 1). Old fruits slowly fade into pale beige or pale gray. L. sulphureus was first described by French mycologist Pierre Bulliard in 1789 as Boletus sulphureus. The current name comes from American mycologist William Murrill. The mushroom is used as a food or as a folk medicine. It contains a large number of biologically active substances that have a beneficial effect on human health. It can therefore be assumed that it could be a new functional food and help with some diseases.

Figure 1: Sulphur polypore (Laetiporus sulphureus). The photo was taken in Čeníkova Pila, Šumava, Czech Republic. © Jiri Patocka.

Food and/or medicine?

Over the generations, this mushroom has become an integral part of some national cuisines particularly for its taste. Besides, it is used in folk medicine for treatment of coughs, pyretic diseases, gastric cancer and rheumatism. Young fruit bodies are edible and their taste is described like crab or lobster. It is highly regarded in Great Britain, Germany, and North America and it is considered as potential source of natural antioxidants [1]. Some people have severe gastrointestinal adverse reactions after eating [2], including vomiting and fever, but this is now thought to be the result of confusion with morphologically similar species such as L. huroniensis and L. gilbertsonii [3].

Nutritional values are 360 kcal/100 g of fresh fruiting bodies, total carbohydrates content was 64.9, proteins 11.9 and fats 5.9 g/100g of the dry mass of fruiting body [4]. Fats are represented by long chain fatty acids with 16 to 20 carbons and ethyl esters of fatty acids with 16 to 24 carbons, as well as sterols (ergosterol, ergosta-7,22-dien-3β-ol, ergosta-7-en-3β-ol and 24 ethylcholestan-3β-ol) [5].

The mushroom is remarkable in many respects and is valued as a significant source of numerous biologically active substances with potential use in many fields of human activity, but especially in medicine [6]. The presence of substances with favorable effect on human health makes the L. sulphureus a new functional food [7]. Experiments with its cultivation on artificial substrates [8], have already begun to be produced in large quantities outside the forest, like, for example button mushroom (Agaricus bisporus) or the oyster mushroom (Pleurotus ostreatus).

Summary

Mushrooms are a rich source of chemical compounds. Such a mushroom is also polypore Laetiporus sulphureus, in which a large number of bioactive substances with cytotoxic, antimicrobial, anticancer, anti-inflammatory, hypoglycemic, and antioxidant activity have been found. This short review summarizes the results of the most important chemical and biological studies of the fruiting bodies and the mycelial cultures of L. sulphureus. Since the ingredients of this edible mushroom have beneficial effects on human health, it could become a functional food.
Bioactive substances

The most important bioactive compounds of this mushroom are lectins Tateno et al., [9–11] polysaccharides [12–18], phenols Olenikov et al., [19,20] terpenoids Léon et al., [21–23], enzymes [24,25], polyene pigments [26], and polyunsaturated fatty acids [27]. The chemical formulas of some of the major bioactive substances L. sulphureus are shown in figure 2.

Pharmacology effects

The study of the pharmacological effects of L. sulphureus bioactive substances stems from the fact that this mushroom has been used for many centuries in the traditional folk medicine of many countries. The identified pharmacological effects confirm well-known, traditional uses and also reveal new possibilities. Cytotoxic, antitumor, antimicrobial, anti-inflammatory, hypoglycemic, and antioxidant effects were observed. A number of biologically active substances found in L. sulphureus are involved in the pharmacological effects. Structures of some are shown in figure 2.

Cytotoxic and anticancer effects

Triterpenoids of lanostane-type isolated from the fruiting bodies demonstrate cytotoxic activity. Eburicoic acid (I, EA) is one of main cytotoxic components isolated from L. sulphureus. This substance suppresses the activation of macrophages, thereby alleviating the progression of inflammatory diseases [6]. EA does not cause any apparent cytotoxicity but significantly inhibits the release of inflammatory mediators, suppressed levels of mRNA expression, inducible nitric oxide synthase (iNOS), cyclooxygenase-2 (COX-2), and proinflammatory cytokines TNF-α, IL-6 and IL-1β. EA also reduces levels of phosphorylated PI3K, Akt, mTOR and NF-κBp65 in LPS-induced RAW264.7 cells [6]. Anti-inflammatory effects have also been demonstrated for acetyl-EA acid found in L. sulphureus var. miniature [28]. Similarly to the lanostane-type tetracyclic triterpenoids which are potential anticancer compounds [29], also illudin-type sesquiterpenoids from the L. sulphureus are responsible for cytotoxicity (He et al., 2015).

Cytotoxic activities were observed also in further compounds isolated from L. sulphureus: phenolic compounds of the benzofuran lignans type egonol (II), demethoxyegonol and egonol glucoside [30], mycophenolic acid (III) and its derivatives [20], laetirobin (IV) [31] which is capable of blocking tumor cell division (mitosis) and invoking apoptosis, and carboxymethyl derivatives of α-(1→3)-D-glucans which have a significant activity to inhibit tumor cell lines metabolism without significantly inhibiting normal cells metabolism [18]. Also, cyclodepsipeptide beauvericin was found in this mushroom [32].

Antimicrobial effect

The first mention of the antibacterial effect of L. sulphureus can be found in the study of Suay et al., [33], who investigated antimicrobial activity of 204 basidiomycetes. Antimicrobial activity of L. sulphureus against a wide spectrum of gram-positive and gram-negative bacteria including methicillin-resistant strain of Staphylococcus aureus (MRSA) and glycopeptide-resistant strain of Leuconostoc mesenteroides was recorded by Ershova et al., [34]. Different fruiting bodies extracts demonstrated an antimicrobial activity against the following strains: Bacillus cereus and B. subtilis, Micrococcus flavus and M. luteus [35], Enterococcus faecium and Proteus vulgaris [36], Bacillus cereus, Enterobacter cloacae, Escherichia coli, Listeria monocytogenes, Micrococcus flavus, Pseudomonas aeruginosa, Salmonella typhimurium and Staphylococcus aureus [37]. Antifungal activity of extracts was described against: Candida albicans [35], Alternaria alternata, Aspergillus wentii, Fusarium tricinctum, Mucoromycous gypseum, Penicillium gladioli and P. griseofulvum (Sakeyan 2006), Aspergillus niger, Botrytis cinerea, Fusarium oxysporum, and Sclerotinia sclerotiorum [38].

Anti-inflammatory effect

The anti-inflammatory effect of L. sulphureus is explained by the presence of exopolysaccharide (EPS) which protects cells from apoptosis by significantly inducing inhibition of pro-inflammatory mediators in cells such as nitric oxide (NO), prostaglandin E2 (PGE2), and tumor necrosis factor-α (TNF-α) without significant cytotoxicity [16] and also by presence lanostane triterpenoids which were identified as eburicoic acid derivatives [28]. These triterpenoids inhibited the NO production and suppressed the production of pro-inflammatory cytokines, mainly inducible nitric oxide synthase, cyclooxygenase-2, interleukin (IL)-1β, IL-6 and TNF-α. Eburicoic acid is the main bioactive metabolite in the L. sulphureus against gastric ulcers in mice model [39].

Hypoglycemic effect

EPS also demonstrated the hypoglycemic effect in rats with single dose streptozotocin induced diabetes and caused an increased proliferation and regeneration of pancreatic islet β cells [13]. Other compound with anti-diabetic potential is dehydrotrametenolic acid (V), also isolated from fruiting bodies. It induces the differentiation of adipocytes in vitro, and
reduces hyperglycemia in mice with non-insulin-dependent diabetes mellitus (Sato et al., 2002). Also EA (1) has antidiabetic and antihyperlipidemic effect and therapeutic potential in the treatment of type 2 diabetes and hyperlipidemia [40-42].

Conclusion

In recent years, mushrooms are increasingly being searched for new biologically active substances. Since mushrooms are an important part of the daily diet of people in many countries, their analysis is valuable in terms of natural chemoprevention. This is also the case with L. sulphureus, which contains biologically significant substances and could be considered a functional food. Several secondary metabolites have been discovered in the mushrooms of this fungus and have been shown to be cytotoxic, antitumor, antimicrobial, anti-inflammatory, and antidiabetic.

Competing interest

I declare that I have no competing financial, professional, or personal interests that might have influenced the performance or presentation of the work described in this manuscript.

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