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THE NUTRITIONAL AND MEDICAL BENEFITS OF *AGARICUS BISPORUS* : A REVIEW

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ABSTRACT

Mushrooms are considered as potential source of many essential nutrients and therapeutic bioactive compounds. *Agaricus bisporus* belongs to *Basidiomycetes* family and the most important commercially cultivated mushroom in the world. The rich nutrients like carbohydrates, proteins, lipids, fibers, minerals, and vitamins present this mushroom as famous healthy food. Moreover, because of the presence of some active ingredients, such as polysaccharides, lipopolysaccharides, essential amino acids, peptides, glycoproteins, nucleosides, triterpenoids, lectins, fatty acids and their derivatives, these mushrooms have been reported to have antimicrobial, anticancer, antidiabetic, antihypercholesterolemic, antihypertensive, hepatoprotective and antioxidant activities. This study is focused on reviewing the recent studies published in the medical and nutritional properties of *Agaricus bisporus*. Investigations on the mushroom have accelerated during the last ten years so that only reports published after 2006 have been considered.

Keywords: *Agaricus bisporus*; button mushroom; nutritional value; medicinal importance; bioactive ingredients

INTRODUCTION

Mushrooms have been recognized as important food items since the ancient times because of their nutritional values and therapeutic properties. In ancient China, people believed that the mushroom establishes human body and health, preserves the youth for as long as possible, it was using as food and medicine (**Safwat and Al Kholi, 2006**). The Greek regarded mushrooms as providing strength for warriors in battles (**Daba *et al*., 2008**), while the Egyptians believed that they were a gift from the god Osiris (**Maihara *et al*., 2012**). The Romans regarded edible mushrooms as the Food of the Gods, and they even had mushrooms on the food list which was served only on festive occasions (**Rahi and Malik, 2016**). The Mayans used psycho-active mushrooms mainly for religious rites and some regions still retain these traditions (**Matsushima *et al*., 2009**).
Auricularia auricularia was the first artificially cultivated mushroom in the world. It was cultivated in 600, followed by other mushrooms like *Flammulina velutipes* (A.D. 800), *Lentinula edodes* (A.D. 1000). The great development in the mushroom cultivation came from France when *Agaricus bisporus* was cultivated for the first time in1600s and *Pleurotus* spp. in USA in 1900s (**Chang, 2008**). To nowaday, only about thirty five mushrooms species have been cultivated commercially, and about twenty ones are currently on an industrial scale. (**Muhammad and Suleiman, 2015**). The global production of cultivated edible mushrooms was 495.127 metric tons in 1961. From 1961 to 2016, mushroom production increased to 10.378.163 metric tons (**FAO, 2016**). Although *Agaricus bisporus* (white button mushroom) still retains the highest overall world production, although the percent of total global production of *Agaricus* sp. has decreased. Today China is leading in global mushroom production. China produces approximately 73 percent of world mushroom production in 2014. The second highest mushroom producing country is Italy, followed by USA (**FAO, 2016**).
In recent years, interest in mushrooms has become increasingly apparent in all over the world due to their nutritional and medical properties. High contents in proteins and polysaccharides associated with low content of fat, which profile is characterized by a higher concentration of mono and polyunsaturated fatty acids than in saturated fatty acids, being also interesting sources of phenolic compounds as well as of some micro and macronutrients (**Rodrigues *et al*., 2015**). The nutritional attributes of edible mushrooms and the health benefiting effects of the bioactive compounds they contain, make mushrooms a health food (**Pereira *et al*., 2012**). Many researchers from different regions of the world confirmed the medicinal importance and nutritional quality of *A. bisporus.* In this review study, we have summarized the recent findings regarding many aspects of the nutritional and medicinal importance of *Agaricus bisporus.*

Nutritional importance of *A. bisporus*

Proximate Compositions

Mushrooms contain a high moisture percentage depending on harvest, growth, culinary and storage conditions (**Guillamón *et al*., 2010). Reis *et al*. (2012)** described moisture (91–92 g/100 g), ash (0.9–1 g/100 g) and energy (29–31 kcal/100 g) in *Agaricus bisporus* samples. **Ahlavat et al. (2016)** analyzed the fruitbodies of *A. bisporus* for its proximate composition and they found that *Agaricus bisporus* fruitbody is rich in protein (29.14%), carbohydrate (51.05%), fat (1.56%) compared to *Pleurotus eous*, *Volvariella volvacea* and *Lentinula edodes*. Tsai *et. al.* (2007), it has been found that the content of the fruits from the carbohydrate 48.9-38.3%, fibers 23.3-17.7% and ash 11.00-7.77% fat 3.92-2.53% in dry *A. bisporus fruitbodies*.

Protein and Amino acid content

Mushrooms are considered as a good source of protein. **Correa *et al*. (2016)** suggested that mushrooms are ranked below animal meats, but well above most other foods, including milk, which is an animal product, concerning the amount of crude protein. Growing substrates (**Gothwal *et al*., 2012**), the stage of development and pre and post-harvest conditions (**Guillamon *et al*., 2010**) can influence the chemical composition and the nutritional value of the cultivated mushrooms. So nutritional composition data of mushrooms published by different authors working with even the same species are variable. The protein content of *A. bisporus* presented by Sadiq *et al*. (2008) with 11.01 %, by **Muszynska *et al*., (2011)** with 25%, by Mohiuddin *et al*. (2015) with 17.7%–24.7% and by **Ahlavat *et al*. (2016)** with %29.14 in different growing substrates.
The amino acid composition of mushroom proteins is comparable to animal protein, which is of particular importance to counterbalance a high consumption

of protein animal food sources, especially in developed countries (**Guillamon *et al*., 2010**). **Kakon *et al*. (2012)** reported that mushroom proteins contain all nine essential amino acids required by humans, enabling their use as a substitute for a meat diet. The amino acids found in *A. bisporus* in the highest amounts are alanine, aspartic acid, glutamic acid, arginine, leucine, lysine, phenylalanine, serine, proline, tyrosine and threonine (**Muszyńska *et al*., 2013**). Moreover, **Muslat *et al*. (2014)** reported that *A. bisporus* contains the essential amino acids useful as a food for the human health including cystine and methionine and threonine and valine and isoleucine and leucine and lysine and tyrosine and phenylalanine.

Carbohydrate and Fiber

Mushroom carbohydrates are not a major source of energy for humans. Digestible carbohydrates include mannitol and glucose, usually present in very small amounts (less than 1% DW) and glycogen (5–10% DW) while non-digestible carbohydrates include oligosaccharides such as trehalose and non-starch polysaccharides (NSPs) such as chitin, β-glucans and mannans, which are the major portion of mushroom carbohydrates (**Cheung *et al*., 2010**). **Reis *et al*. (2012)** reported that mannitol and trehalose were abundant sugars in the studied cultivated edible mushrooms, mannitol predominated in *A. bisporus* (white and brown mushrooms). Dietary fiber includes components of fungal cell walls such as chitin (Maftoun *et al*., 2015), hemi-celluloses, mannans and beta glucans play a key role in some healthy properties of mushrooms (**Cheung, 2009**). **Nitschiske *et al*. (2011)** determined that chitin content of *A. bisporus* was 9.60 g/100 g DM. Cherno *et al*. (2013) reported that *A. bisporus* contains 2 times more chitin than *P. ostreatus*. Similirly, Vetter (2007) determined that *A. bisporus* had higher chitin level than had *P. ostreatus, L. edodes.*

Mineral content

Mushrooms are known to be an excellent accumulator of minerals from the environment in which they grow. **Owaid (2015)** reported that *A. bisporus* a good source of K, Fe, Zn, Cu, Na, Se,Co and Mn . The main constituents in mushroom fruiting bodies are potassium and phosphorus and are usually followed by Ca, Mg, Na and Fe, Zn (**Guillamon *et al*., 2010; Falandysz and Borovička, 2013**).
Mohiuddin *et al*. (2015) *Agaricus bisporus* fruitbodies from different locations of Bangladesh, were analysed for their minaral content profile . The mineral content of samples ranged from 0.54–1.58% for potassium and 37.2–61.9 µg/g for sodium, 143.6–396 µg/g for ferrum, 54.6–163.4 µg g-1 for copper, 36.6–58.0 µg/g for zinc, 56.2–91.1 µg/g for manganes. Caglarirmak (2009) determinated that zinc (8.1–7.0 mg/kg), ferrum (7.4–7.9 mg/kg), phosphore (7.4–7.9 mg/kg), magnessium (88.0–76.3 mg/kg), potassium (213.3–238.8 mg/kg), sodium (2652–2500 mg/kg) and calcium (534.2–554.8 mg/kg) contents, while **Ahlavat *et al*. (2016)** they found that sodium (500.8 mg/kg), potassium (4.21%) and selenium (1.34 mg/kg) of *A. bisporus* fruitbodies.
Selenium is an essential micronutrient for humans and animals (**Lu and Holmgren, 2009**). **Turto *et al*. (2010)** reported that most wild growing and farm edible mushroom species including *A. bisporus* are poor selenium sources with a concentration of less than 1 µg/g (dried weight). On the other hand, **Maseko *et al*. (2013)** suggested that the Se concentration in *A. bisporus* cultivated in growth compost irrigated with sodium selenite solution can be increased. They determined that selenium contents of mushroom proteins increased from 13.8 to 60.1 and from 14.1 to 137 µg/g in caps and stalks by irrigated with sodium selenite solution. **Maseko *et al*. (2014)** investigated the effect of dietary supplementation with Se-enriched *A. bisporus* on cytosolic glutathione peroxidase-1 (GPx-1), gastrointestinal specific glutathione peroxidase-2 (GPx-2), thioredoxin reductase-1 (TrxR-1) and selenoprotein P (SeP) mRNA expression and GPx-1 enzyme activity in rat colon and they reported that the activity of colonic GPx-1 in rats provide evidence for its potential anti-cancer use.

Vitamins

Some authors have considered mushrooms as a good source of vitamins. It was reported that the most abundant vitamin in *Agaricus* is niacin, followed by riboflavin. Other vitamins include vitamin B1, vitamin B3, L-ascorbic acid and α-tocopherol (**Bernas & Jaworska, 2016**). **Çağlaırmak, (2009)** also reported that brown *A. bisporus* (portobello mushroom) is a good source of folic acid (0.09–0.08 mg/ kg), riboflavin(0.27–0.29 mg/kg), niacin (3.6–2.9 mg/kg), and thiamin (0.085–0.09 mg/kg), while not rich in vitamin C content. On the other hand, Furlany and Godoy (2008) determined that the mean level of vitamin B_1 for fresh *A. bisporus* was 0.03 mg/100 g while vitamin B_2 for the *A. bisporus* mushroom was 0.25 mg/100 g. They reported that although Vitamin B_2 contents in *A. bisporus, Lentinula edodes* and *Pleurotus* spp. with exception of mushroom in conserve, are higher than the levels present in many vegetables, mushrooms could not be considered as significant sources of B_1 and B_2 vitamins, since their contribution in terms of these vitamins to the diet is not significant although they may contribute to the sums of these nutrients in the diet.
Mushrooms are a natural source of vitamin D. **Ahlavat *et al*. (2016)** determined that vitamin D content of *A. bisporus* is 984 IU/g. It is found in larger quantities in wild mushrooms compared to cultivated mushrooms (**Simon *et al*., 2011**). The absence of vitamin D in cultivated *Agaricus bisporus* could be due to cultivation in dark (**Reis *et al*., 2012**). **Roberts *et. al.* (2008)** reported treating ultraviolet toward fruiting bodies of *A. bisporus* in recommended dosages by Processed Foods Research Unit (PFRU). They discovered that it will lead to the accumulation of significant quantities of vitamin D_2 in the treated fruiting bodies. This is important for the health of bones.
Ergosterol is a biological precursor to vitamin D_2 and is a component of fungal cell membranes. The ergosterol contents of *A. bisporus* (white), *A. bisporus* (brown), *A. bisporus* (Portabella), varied in the ranges 39.5–56.7 mg/100 g f.w (**Teichmann *et al*., 2007**). **Shao *et al*. (2010)** isolated ergosterol in both white and brown *A. bisporus* mushrooms and they reported that the ergosterol content of brown and white button mushrooms correlated with their antioxidant activities.

Fatty acids

Agaricus bisporus is low in fat content, but they contain some essential fatty acids such as linoleic acid. **Barros *et al*. (2008)** reported that wild *Agaricus* spp. contained a lower value of monounsaturated fatty acids but also a higher content of polyunsaturated fatty acids than the commercial species, due to the higher contribution of linoleic acid. Total amounts of fatty acids ranged from 180 to 5818 mg/kg dry matter in the *A. bisporus* strains tested and almost 90% of the fatty acids in *A. bisporus* is linoleic acid on average (**Baars *et al*., 2016**). **Sadiq *et al*. (2008)** reported that fatty acids detected in *A. bisporus* were: linoleic, caprylic, palmitic, stearic, oleic, eicosanoic and erucic acids and linoleic acid was dominant fatty acid in *A. bisporus* that accounts for 44.19 % of total fatty acid identified. **Ozturk *et al*. (2011)** find that linoleic (61.82–67.29%) and palmitic (12.67– 14.71%) acids were dominant fatty acids in *A. bisporus* among the 13 fatty acids detected in the oils. The fatty acid contents of *A. bisporus* are reported also mainly linoleic and palmitic and stearic acids by **Shao *et al*., (2010).**
Linoleic acid is essential for human health and has many beneficial effects on human health. They reduce atherosclerosis by interesting with HDL in the blood (**Sadiq *et al*., 2008**). **Hossain *et al*. (2007)** determined that the concentration of linoleic acid in *A. bisporus* was 20- and 5-folds more than those in the *Ganoderma lucidum* and *Pleurotus ostreatus*, respectively.

Soluble sugar and volatile compounds

Flavor and taste represent the most important quality attribute contributing to the widespread consumption of cultivated mushrooms. The taste of mushroom is the umami or palatable tastes or the perception of satisfaction, which is an overall food flavor sensation induced or enhanced by monosodium glutamate (MSG). The contents of MSG-like (aspartic and glutamic acids) and sweet components (alanine, glycine, and threonine) total soluble sugars and polyols were considerately higher in edible mushrooms and might be sufficient to suppress and cover the bitter taste arising from the contents of bitter components. The content of monosodium glutamate-like components is in the range from 10.6 mg/g to 13.5 mg/g and similar to those of sweet components (11.4–14.3 mg/g) but lower than those of bitter components (19.7–26.9 mg/g) (**Tsai *et al*., 2007**).
For *A. bisporus* mannitol was the most abundant sugar (**Baars *et al*., 2016**). **Tsai *et al*. (2007)** also reported that mannitol was the major soluble sugar in fresh *A. bisporus* fruitbodies while glucose was the second highest and its contents were in the range of 17.6–28.1 mg/g in different mature stages. Moreover, they suggested that the high amount of sugars and polyols, especially mannitol, would give rise to a sweet perception, and not to the typical mushroom taste.
Taste in mushrooms is linked both to volatile and non-volatile compounds. The terpenes, lactones, amino acids, and carbohydrates of their composition determine a range of precious aromas and flavor properties to their fruiting body and mycelial biomass (**Smiderle *et al*., 2012**). **Taşkın *et al*. (2013)** identified totally 28 aroma compounds of *A. bisporus*. In this study, alcohols were detected to be the major compounds and 1-octen-3-ol was found to be the major alcohol.

Medicinal importance of *A. bisporus*

There is an increasing interest in extracting bioactive ingredients from mushrooms for developing functional foods. *A. bisporus* have a very good history of using in many traditional therapies. The use of *A. bisporus* extracts and/or its bioactive compounds as antioxidant, anti-cancer and anti-inflammation is increasing in the world against many human diseases such as coronary heart diseases, diabetes mellitus, bacterial and fungal infections, disorders of the human immune system and cancers (**Dhamodharan and Mirunalini, 2010**). Although there have been relatively few direct intervention trials of mushroom consumption in humans, those that have been completed to date indicate that mushrooms and their extracts are generally well-tolerated with few, if any, side effects.(**Volman *et al*., 2010**).
Antioxidant (**Ghahremani-Majd and Dashti, 2015**) and anti-diabetic (**Mao *et al*., 2013**) antibacterial properties (**Ndungutse *et al*., 2015**) of *A. bisporus* were reported some studies (**Öztürk *et al*., (2011)** *A. bisporus* extracts can be potentially applied in Alzheimer's disease treatment reported that due to their

acetylcholinesterase and butyrylcholinesterase inhibiting activity. **Mohamed (2012)** determined that a total 174 significant metabolites in ethanolic extracts of *Agaricus bisporus* samples by using GC/MS method between <1 to 83% (w/w) classified into twelve categories. These metabolites had numerous medicinal activities such as anti-cancer, anti-cardiovascular diseases, anti-hypercholesterol, antimicrobial, hepatoprotective, human health supporting and immune enhancer. The main medical properties of *A. bisporus* were presented in the following section.

Anticancer

Cancer is one of the deadliest diseases in the world. Recently, purified some natural active component from mushrooms such as polysaccharides exhibited the significant anti-cancer activity toward various cancer cell lines. Basidiomycota is known to present medicinal characteristics, which are being attributed to its glucan and other polysaccharide. The polysaccharides generally belong to the beta-glucan family of compounds and appear to exert their anti-tumorigenic effects via enhancement of cellular immunity.

A. bisporus contains bioactive compounds that have been shown to exhibit immunomodulating and anticancer properties. The Canadian Cancer Society recommends consumption of *A. bisporus* mushroom because of its effectiveness against human diseases. **Zhang *et al*. (2014)** reported that brown *A. bisporus* polysaccharide possessed strong immunostimulatory and antitumor bioactivity *in vivo* and *in vitro*.

A. bisporus contain three main polysaccharides α- glucan, β-glucan and galactomannan (Smiderie *et al*., 2011) and galactomannan is main polysaccharide by 55.8% (**Smiederie *et al*., 2013**). **Ren *et al*., (2012)** reported that the most common glucans extracted from *A. bisporus* are (1→3), (1→6)-d-glucans. Consumption of fruit juice enriched with α-glucans from *A. bisporus* (5 g glucans/day) lipopolysaccharide induced tumor necrosis factor (TNFα) production by 69%. No effects on interleukin (IL)-1b and IL-6 and decreased production of IL-12 and IL-10 was observed (in vivo) (Volman *et al*., 2010). On the other hand, A. *bisporus* does not present very high β-glucan content (8–12 g/100 g dm). Low beta-glucan content in *Agaricus bisporus* is also reported by **McCleary and Draga (2016).**

A. bisporus has got potential health benefits for improving mucosal immunity. The dietary intake of *A. bisporus* significantly accelerates secretory immunoglobulin A secretion (**Jeong *et al*., 2012**). *A. bisporus* fruiting bodies extracts express an immunostimulating effect on activated human peripheral blood mononuclear cells (PBMCs) and induce synthesis of interferon gamma (IFN-γ) (**Kozarski *et al*., 2011**). Extracts from *A. bisporus* have been shown to inhibit cell proliferation of HL-60 leukemia cells and other leukemia human cell lines via the induction of apoptosis. (**Jagadish *et al*., 2009**). **Novaes *et al*. (2011)** reported that arginine present in the *A. bisporus* fruitbodies delays tumor growth and metastasis and should be used as dietary supplements for patients with cancer. **Kanaya *et al*. (2011)** reported that *A. bisporus* would suppress aromatase to decrease the risk of breast cancer.

Moreover, *A. bisporus* contained the high amount of lovastatin (**Chen *et al*., 2012**). **Yang *et al*. (2016**) demonstrated that lovastatin exerts anti-cancer effects in the triple-negative breast cancer cell line MDA-MB-231.

Palomares *et al*. (2011) reported that phytochemicals extracted from *Agaricus bisporus* suppress aromatase activity, inhibit breast cancer (BC) cell proliferation, and decrease mammary tumor formation *in vivo*. They suggested that anti-aromatase phytochemicals are present in plasma with daily consumption of 100-130g whole WBM, but not at high enough concentrations to significantly reduce estrogen levels from baseline in 12 weeks. Moreover, **Chen *et al*. (2006)** reported that the major active compounds in *A. bisporus* are unsaturated fatty acids such as linoleic acid, linolenic acid, and CLA which have been shown to inhibit aromatase activity. **Roupas *et al*. (2012)** also reported that an inhibition of aromatase activity and subsequent reduction of estrogen using extracts of mushroom that provide a physiologically suitable mechanism for influents on estrogen receptor positive tumors.

Although **Hong *et al*. (2008)** reported that daily intake and average of consumption frequency of mushroom were inversely associated with breast cancer risk, and a strong inverse association was found in post-menopausal women. **Shin *et al*. (2010)** suggested that a decreased risk of breast cancer from mushroom consumption by pre-menopausal women.

Antihyperlipidemic

Hyperlipidemia, represented by increased levels of triglycerides or cholesterol, is a dominant risk factor that contributes to the progression and development of subsequent cardiovascular disease and atherosclerosis, which is one of the most serious diseases in humans (**Esmaillzadeh and Azatbakth, 2008**). Phytosterols derive reduce cholesterol absorption, thereby having the capacity to lower plasma cholesterol and LDL cholesterol (**Lin *et al*., 2009**). The identified sterols in A. bisporus are ergosta-7,22-dienol, ergosta-5,7-dienol, and ergosta-7- enol (fungisterol) (**Teichmann *et al*., 2007**).

Lovastatin is a statin drug, used for lowering cholesterol (hypolipidemic agent) in those with hypercholesterolemia to reduce the risk of cardiovascular disease (**Xu *et al*., 2013**). **Yang *et al*. (2016)** demonstrated that lovastatin exerts anti-cancer effects in the triple-negative breast cancer cell line MDA-MB-231. **Chen *et al*. (2012)** reported that Agaricus bisporus contained the 565.4 mg/kg of lovastatin and suggested also that white button mushroom A. bisporus reduce the cholesterol level in serum and/or liver. **Jeong *et al*. (2010)** examined the hypothesis that intake of the fruiting bodies of A. bisporus regulates antiglycemic and anticholesterolemic responses in rats fed a hypercholesterolemic diet (14% fat and 0.5% cholesterol) and rats with type 2 diabetes induced by injection of streptozotocin (STZ) (50 mg/kg body weight) and they reported that A.bisporus mushroom had both possesses antiglycemic and antihypercholesterolemic effects in rats. Moreover, it has a positive influence on lipid metabolism and liver function.

Antidiabetic

A. bisporus contains high levels of dietary fibers and antioxidants including vitamin C, D, and B12; folates and polyphenols that may provide beneficial effects on cardiovascular and diabetic diseases (**Jeong *et al*., 2010**). **Calvo *et al*. (2016)** reported that *A. bisporus* contain a variety of compounds with potential anti-inflammatory and antioxidant health benefits that can occur with frequent consumption over time in adults predisposed to type 2 diabetes. **Yamaç *et al*. (2010)** reported that the oral application of high doses of *A. bisporus* extract may result in decreased severity of streptozotocin-induced diabetes in rat. The streptozotocin induced diabetic male Sprague-Dawley rats fed the *A. bisporus* powder (200 mg/kg of body weight) for three weeks had significantly reduced triglyceride (TG) and plasma glucose concentrations to 39.1% and 24.7% respectively, liver enzyme activities, aspartate aminotransferase and alanine aminotransferase to 15.7% and 11.7% respectively, and liver weight gain (**Jeong *et al*., 2010**). Volman *et al*. (2010) investigated the effects of alpha-glucans from *A. bisporus*. They reported that consumption of alpha-glucans of *A. bisporus* mushroom lowered producing lipopolysaccharide-induced TNFa by 69% compared to the control group, whereas no effect on IL-1b and IL-6 was observed.

Calvo *et al*. (2016) reported that *A. bisporus* contain a variety of compounds with potential anti-inflammatory and antioxidant health benefits that can occur with frequent consumption over time in adults predisposed to type 2 diabetes. **Kanaya *et al*. (2011)** suggested that *Agaricus bisporus* intake may be a viable dietary choice to prevent liver steatosis, which is an early reversible stage of nonalcoholic fatty liver disease in postmenopausal women.

Antioxidant

Total phenolics and antioxidant properties of *A. bisporus* have been reported by many authors (**Ramirez-Anguiano *et al*., 2007; Savoie *et al*., 2008; Barros *et al*., 2008**). *A. bisporus* mushrooms, especially portabellas (brown *A. bisporus*), had higher antioxidant capacity relative to *Lentinula edodes, Pleurotus ostreatus, Pleurotus eryngii* and *Grifola frondosa*. **Liu *et al*. (2013)** determined the main phenolic compounds in ethanolic extract of *A. bisporus* like gallic acid, protocatechuic acid, catechin, caffeic acid, ferulic acid and myricetin and suggested that the ethanolic extract of this mushroom had potent antioxidant effect, and could be explored as a novel natural antioxidant. **Oms-Oliu *et al*. (2010)** reported that phenolic content of fresh-cut *A. bisporus* mushrooms was 100.78–100.32 mg/100 g fw. Ergothioneine content ranged from 0.21-045 mg/g dw with white *A. bisporus* and brown *A. bisporus* (portobello) (**Dubost *et al*., 2007**)

Phenolic compounds have been reported as the major antioxidant components in mushrooms (**Barros *et al*., 2008**). A close relationship between antioxidant activity and phenolic contents and suggested that phenolic compounds could be the foremost contributors to the antioxidant activity of edible macrofungi (**Kim, 2008; Guo *et al*., 2012**). Contrastly, **Palacios *et al*. (2011)** reported that *A. bisporus* presents the high contents of phenolics, although this species has got a low antioxidant activity.

Chitosan NPs of *A. bisporus* had antioxidant effects. All potential antioxidant properties reflect on positive anticancer effect (**Dhamodharan and Mirunalini, 2012**). **Neyrinck *et al*. (2009)** fungal chitosan decreases feed efficiency, fat mass, adipocytokine secretion and ectopic fat deposition in the liver and the muscle. In this way it counteracts some inflammatory disorders and metabolic alterations occurring in diet-induced obese mice.

Tocopherols (TCP) are fat-soluble antioxidants but also seem to have many other functions in the body. Many of them have vitamin E activity. **Reis *et al*. (2012)** determined α-tocopherol (0.23 µg/100 g fw and 0.28 µg/100 g fw), β-tocopherol (0.85 µg/100 g fw and 0.71 µg/100 g fw), γ- tocopherol (1.51 µg/100 g fw and 7.63 µg/100 g fw) and δ-tocopherol (2.60 µg/100 g fw and 2.54 µg/100 g fw) in fruit bodies of white *A. bisporus* and brown *A. bisporus*, respectively.

Seratonin is a biochemical compound that has got antioxidant ability (**Sarikaya and Gulcin, 2013**). Antioxidant actions of seratonin and its ability to prevent the progress of Alzheimer's disease were also referred by **Quchi et al. (2009). Muszynska *et al*. (2011)** reported that the content of seratonin in the extracts of *A. bisporus* was high (5.21 mg/100 g dw).

Antimicrobial

Some previous studies suggested that the extracts of *A. bisporus* prepared with methyl alcohol revealed antimicrobial activities against some bacteria, yeasts, and dermatophytes (**Akyuz *et al*., 2010; Abah and Abah, 2010**). Microbial inhibition of *A. bisporus* extracts has been reported also by **Ndungutse *et al*. (2015).** They suggested the potential use of the stipes of *A. bisporus* as natural antimicrobials. **Tehrani *et al*., (2012)** determined that aqueous total protein extracts of the cultivated *A. bisporus* possess significant antibacterial activity, particularly against *S. aureus* and Methicillin-Resistant *S. aureus.*
Silver nanoparticles (AgNPs) are one of the most commonly used metallic nanoparticles, which possess potent antibacterial and antifungal characteristics, as shown in **Figure 1**. *Agaricus bisporus* is considered an important factor for biosynthesis of silver nanoparticles (AgNPs) **(Owaid *et al*., 2017). Owaid and Ibraheem, (2017**) reported that *A. bisporus* had the second level (about 11%) after oyster mushroom *Pleurotus* sp. in synthesis important nanoparticles. **Sudhakar *et al*. (2014)** synthesized the AgNPs using the *A. bisporus* extract. They suggested that AgNPs may have an important advantage over conventional antibiotics in that it kills pathogenic microbes and no organism has ever been reported to readily develop resistance to it. **Ul-Haq *et al*. (2015)** characterized the biosynthesized AgNPs by UV-Visible spectroscopy, FT-IR, and TEM. They determined that the AgNPs from the mushroom *A. bisporus* have shown a higher zone of inhibition against Methicillin-Resistant *Staphylococcus aureus* strains than *Helvella lacunosa, Ganoderma appalanatum, Pleurotus florida* and *Fomes fomenterieus*. **Ul-Haq *et al*. (2015)** researched that the synergistic effect of *A. bisporus*-AgNPs with Gentamicin and Ceftriaxone antibiotics and they determineted an inhibition zone of 26 mm and 25 mm respectively. Also, antibacterial activity of the synthesized *A. bisporus*-AgNPs was investigated by **Mirunalini *et al*. (2012)** against Gram-positive bacteria like *Staphylococcus aureus* and by (**Dhanasekaran *et al*., 2013**) against *S. typhi*, *Proteus* sp. *Enterobacter* sp. and *Klebsiella* sp.

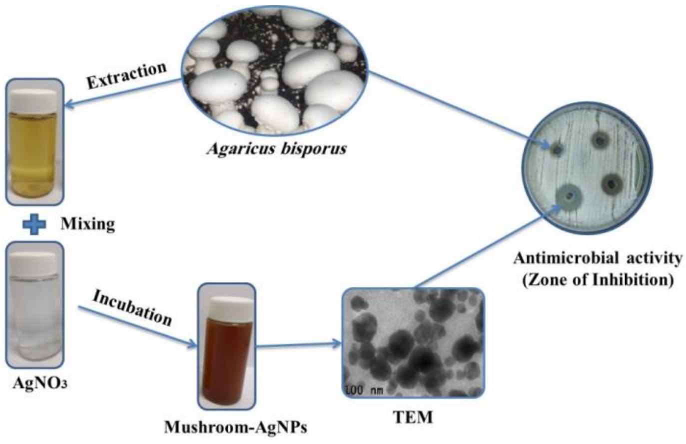

Figure 1 Biosynthesis silver nanoparticles using mushroom *Agaricus bisporus*

CONCLUSION

A bisporus may provide significant support against malnutrition due to high nutritional values especially in developing and undeveloped countries. Consumption of *A. bisporus* is not useful in case of nourishment, but also existing the medicinal benefit of mushroom, especially as anticancer, anti-cardiovascular disease, antidiabetes, antioxidant, and antimicrobial. In the last decades, edible mushroom has been used as a source of treatment or health food supplements increasingly. Most of the investigations have shown that nutraceutical therapy is a promising source of new therapeutics against many life-threatening diseases. Although bioactive molecules isolated from *A. bisporus* may represent an important advance for their characterization as a source of drugs, more clinical data are needed for the determination of medicinal benefits of *A. bisporus*.

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