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Bioactive and Nutraceutical Properties of Mushrooms in Body Aesthetic

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Abstract

Mushrooms are fruiting bodies of fungi, some species of edible mushrooms being used as part of traditional diets, such as a Mediterranean. In this sense, edible mushrooms have emerged as a viable alternative increasingly common in the Brazilian table due to their nutritional properties. This article aimed to evaluate the benefits of the bioactive and nutritional properties of mushrooms on body aesthetics. This study consists of a literature review where an electronic search was performed in the United States: PubMed, Science Direct,

Cochrane Library, Scientific Electronic Library, Online Databases (SciELO), Scopus, Web of Science, Medline via Proquest and Capes Periodicals covering the years 1989-2019, using the terms "Nutrient Mushrooms" "Mushrooms, Vitamins, Food Supplementation" "Mushrooms and Nutrition and Micronutrients" "Mushrooms and Nutrition and Macronutrients" "Nutrient Mushrooms and Nutraceuticals "Mushroom and aesthetics" Mushroom and antioxidant. Mushrooms are rich in proteins with good bioavailability, low lipid content and excellent fiber source that can be used as nutritional, advanced for their bioactive compounds, polyphenols and other biological compounds that perform body aesthetic activities.

1 Introduction

The Food Guide for the Brazilian population (BRAZIL, 2014) deals with food by simply raising the act of eating beyond nutrient intake. But, rather, as a complex multifactorial act that includes nutrients related to the foods that contain them, the arrangement of these foods, the way of eating, and, above all, the social and cultural dimensions of eating practices, demonstrating that eating has become an act besides merely satiating hunger.

Thus, it is recognized that the concern with physical appearance has grown and has been a determining factor in the choice of food when assembling a dish, so that undesirable effects are avoided and some aesthetic merit is reached, determined either by individual body dissatisfaction or social pressure to appear within a pattern considered interesting (ALVARENGA, KORITAR, MORAES, 2019).

Man has sought acceptance of his physical appearance since time immemorial. In this sense, with the explosion of social media, the search for a so-called perfect appearance has motivated restrictive diets that are not concerned with caring for well-being, but that can lead to eating disorders and nutritional deficit (WITT, SCHNEIDER, 2011).

On the other hand, the popularization of social networks allowed greater access to informa-

tion and nutritional information itself (WITT, SCHNEIDER, 2011). From this, an increasing portion of the population sought to vary the diet so that aesthetic gains were achieved. Through macronutrient-based food substitutions that were supposed to be avoided and desirable proximate compounds, there was a search for super foods to achieve levels of health and beauty based on food.

In this sense, edible mushrooms have emerged as a viable alternative increasingly common at the table of the Brazilian, who learned to eat the fungus with oriental immigration (BACH, 2017). The consumption of mushrooms becomes interesting when observing that the most consumed species, such as shimeji, are rich in proteins of good bioavailability and, recently, their nutraceutical capacities, arising from their bioactive compounds, polyphenols and other biologically compounds, began to be researched assets that can act on the organism (BACH, 2017).

The low lipid concentration of the mushroom, regardless of the species, made the fungus a desirable option due to its low caloric content (FURLANI, 2004). Associated with the fact that it is also a good protein option for vegetarian and vegan patients, there is a search for functional properties of foods that could develop anti-aging actions in the body, such as antioxidants and modulators of intestinal microbiota.

There is also evidence that mushrooms can be excellent sources of dietary fiber, such as β-glucans, biotin and vitamins, whose total content may vary according to the substrate where it is grown (CAVALCANTE, 2008).

The evidence that there are physiological functional compounds in mushrooms has also increased food production, making cultivation an economically viable alternative for traditional farmers (ORSINE, BRITO, NOVAES, 2013). Thus, the objective is to evaluate the bioactive and nutraceutical properties of edible mushrooms in improving the body's aesthetic profile.

2 Methods

This study consists of a li-

terature review, where an electronic search was performed in the United States Library of Medicine (PubMed), Science Direct, Cochrane Library, Scientific Electronic Library, Online databases (SciELO), Scopus, Web of Science, Medline via Proquest and Periodicos Capes covering the years between 1989 and 2019, using the terms of reference "Mushroom Nutrients" "Mushroom, Vitamin, Food Supplementation" "Mushroom and Nutrition and Micronutrients" "Mushroom and Nutrition and Macronutrients" "Mushroom Nutrients and Nutraceuticals" "Mushroom and Aesthetic" "Mushroom and Antioxidant".

The presentation of the figures found in each database is illustrated in the organization chart below (Chart 1).

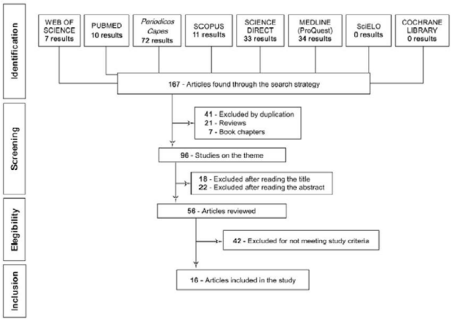


Chart 1 - Flowchart showing the selection process of the studies used in this review.

3 Development

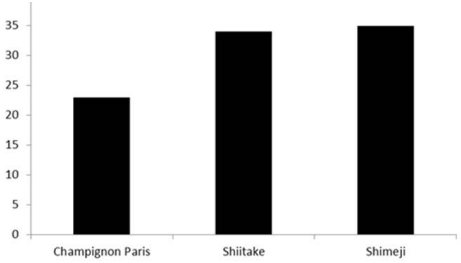
3.1 Mushrooms and their composition with macronutrient

The macronutrient composition of edible mushrooms varies according to species, soil, management and substrate (SUN *et al.*, 2017). Mushrooms are made up primarily of water (85 and 95%), which makes an extremely perishable food (Breene et al., 2000; ORSINE et al., 2013; SUN *et al.,* 2017). Dry, their mass varies between 5 to 15% of their fruiting body.

Orsine (2013) points out that the high water concentration of the mushrooms makes the storage condition of the fungus extremely important. Pleurotus mushrooms are very sensitive and, once out of perfect condition, can cause serious gastrointestinal complications. Therefore, refrigeration at 2ºC is recommended for up to 9 days (XIAO, et al., 2011).

In addition to being palatable, mushrooms have low caloric content (Graph 1) due to the redu-

ced lipid content (BACH, 2017). In this sense, also protein sources considered excellent and a significant portion of dietary fibers.



Graph 1: Illustrates edible species of mushrooms and the caloric content (Kcal) in 100 grams of the food.

Mushrooms have been identified by many researchers as nutraceutical or physiological functional foods (FURLANI and GODOY, 2005). Consumption and commercialization have been growing in Brazil, and this is currently due to greater disclosure of its nutritional and medicinal value and because its price has become a little more accessible to the population (FURLANI and GODOY, 2007). From the nutritional point of view, they are considered a good source of protein, due to their high protein value, in addition to having a low lipid content, as well as being a source of minerals, dietary fibers, niacin, biotin and vitamins B1, B2 and C (BREENE, 1990; FURLANI; GODOY, 2005).

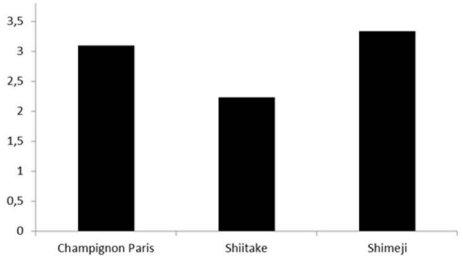
3.1.1 Protein Composition

Analyzing species on a dry basis, protein percentages were found that varied between 12 and 56.3% (BACH, 2017), corroborating previous results of Taveira and Novaes (2007), already mentioned. The advantage of the mushroom over other protein sources of plant origin is visible in the analysis of the amino acid count, since mushrooms have all the essential amino acids, which, not endogenously produced, must be supplied through food intake (PHAT; MOON ; LEE, 2016). These amino acids are also responsible for the umani flavor of mushrooms (PHAT; MOON; LEE, 2016).

When comparing the amount of its protein with other sources of high bioavailability, such as meat, its protein content is lower, but higher when compared to most protein sources whose origin is

vegetable (BACH, 2017).

The comparison between different species (Graph 2) in different studies and by different methods of analysis carried out by Manzi (1999) attributes the variation to the chitin content referring to the samples used. In 2001, Manzi assessed that cooking does not reduce the protein content of the species he studied.



Graph 2: Illustrates edible species of mushrooms and the protein content in 100 grams of the food.

Mushrooms have good sources of protein. Studies prove that the protein contained in it has 60 to 70% digestibility and concluded that amino acids comprise 25-40% of its total content (BREENE, 1990). Collected data indicate that the content of this macronutrient varies from 10.5 to 34.8% on a dry (fresh) basis and on a wet (preserved) basis, reaching a content of 2 to 3% (FURLANI, and GODOY, 2005).

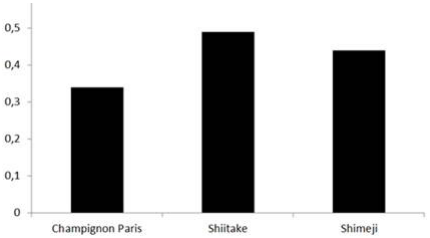
For most foods, the protein content is calculated using a correction factor 6.25 from the organic nitrogen content present which assumes that the proteins contain 16% nitrogen and are fully digestible. However, mushrooms have a significant amount of non-protein nitrogenous compounds, in ıe form of chitin, in their cell ⁄alls and such compounds are not igestible. In order not to overesmate such mushroom content, ıctor 4.38 is adopted, as this alue assumes that only 70% of ..ıe nitrogenous compounds in the mushroom are digestible by the human body (BREENE, 1990).

Analyzes carried out by FURLANI and GODOY (2007) of the centesimal composition in three different species of mushrooms considered the most consumed in Brazil, such as champignon, shitake and shimeji, showed significant differences for protein levels. The average value for all species was approximately 23%.

3.1.2 Lipid Composition

The low lipid levels of the mushrooms (Graph 3) make them interesting alternatives when there is an indication of caloric restriction. Furlani (2004) compiled several studies on this macronutrient in mushrooms and the results always refer to low quantities.

Therefore, it is worth mentioning that the lipids present in mushrooms are unsaturated fatty acids, especially those of the omega 3 and 6 types, which have great antioxidant potential (BACH, 2017).



Graph 3: Illustrates edible species of mushrooms and the lipid content in 100 grams of the food.

Mushrooms have low fat content and caloric values, ranging from 1.1 to 8.3% on a dry basis, giving healthy characteristics to this food, being well recommended in many low calorie diets (FURLANI and GODOY, 2005 and HELENO *et al,* 2009). The crude fat found in mushrooms contains all classes of lipid compounds, including free fatty acids, mono, di and triglycerides, sterols, sterol esters and phospholipids. The most abundant are linoleic, oleic and palmitic fatty acids.

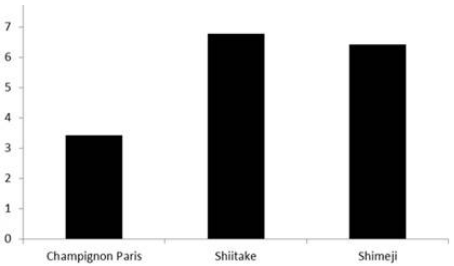
In this sense, linoleic acid belonging to the group of omega 6 fatty acids, is transformed by the human organism into arachidonic acid and other polyunsaturated fatty acids. Omega 6 derivatives of linoleic acid play an important physiological role: they participate in the structure of cell membranes, influencing blood viscosity, vessel permeability, anti-aggregating action, blood pressure, inflammatory reaction and platelet functions. Studies prove the effects caused by the substitution of saturated fat for monounsaturated fat in the diet, with a reduction in the levels of total cholesterol and LDL, without significantly altering the levels of HDL (MORAES and COLLA, 2006; BREENE, 1990; FERREIRA, 2011).

FURLANI AND GODOY

(2007), highlighted that the presence of this macronutrient in the champignon presented with a content of 5.4% on a dry basis, the shiitake with 4.4% and the shimeji, as in the other mushrooms, was low with 4.30%.

3.1.3 Carbohydrate Composition

Several studies compiled by Bach (2017) indicate a glycidic content of different species of mushrooms as varying between 13 and 65%, values higher than those found by Taveira and Novaes (2007), earlier. The difference is attributed to the different specimens evaluated in the studies (Graph 4).



Graph 4: Illustrates edible species of mushrooms and the carbohydrate content in 100 grams of the food.

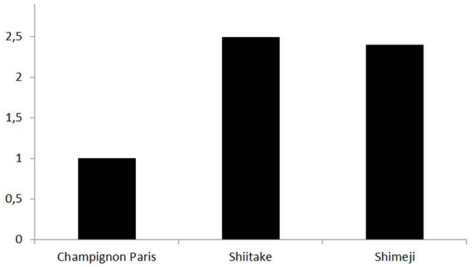
Most of the carbohydrate content present in edible mushrooms are oligo and polysaccharides, including chitin, α and β-glucan, mannan, xylan and galactan (BACH, 2017). Polysaccharides of the type β-glucans interact with the immune system, especially with T cells, NK and B lymphocytes, strengthening immunity (ORSINE, *et al.*, 2013).

The non-digestibility of these polysaccharides abundant in species makes edible mushrooms excellent sources of dietary fiber (BACH, 2017; ORSINE, 2013; MANZI, 2001).

Carbohydrates are part of the chemical composition of the mushroom and are considered one of its main constituents and are present with values of 3 to 28%. They contain pentoses (xylose and ribose), hexoses (glucose, galactose, maltose), sucrose and other sugars (mannitol, inositol, glucosamine) (FURLANI and GODOY, 2005).

The composition of the fiber fraction of mushrooms is mainly composed of β-glycans, chitin and hemicellulose and have immuno-

modulating properties (Graph 5) (FERREIRA, 2011).



Graph 5: Illustrates edible species of mushrooms and the fiber content in 100 grams of the food.

3.2 Mushrooms and their composition with micronutrients

Mushrooms, which were best known at first through culinary and medicinal preparations by eastern civilizations (CHANG, 1996), are appreciated by the consumer market due to information about their nutritional value and their pleasant taste. In recent years, research has increased and focused on the nutritional details of mushrooms, bringing new perspectives regarding their potential health benefits. It was revealed that the bioactive constituents of mushrooms also have anti-tumor, anti-cancer, anti-atherosclerotic inhibition, as well as anti-aging, antioxidant, antibacterial and melanosis inhibiting properties (TANG *et al.,* 2016).

Mushrooms are currently considered to be foods of nutraceutical, functional and physiological value, which has served as a stimulus for national production and originated investments in the sector through new producers focused on more productive techniques. In addition to the species already known for their excellent quality, such as champignons, shiitake and shimeji, studies have been done regarding the introduction of new species on the market (Furlani, 2004).

Among the most consumed species, shiitake is popularly known as a food capable of strengthening and restoring the organism, being used to treat diseases related to the immune system, with effects described as antiviral and antitumor, from its aqueous extract (CHANG; MILES , 1989).

It is believed that mushrooms, although little explored in relation to the nutrients in their composition, can be indica-

ted as good sources of vitamins, since data from international literature, regarding their determinations, as well as centesimal compositions made, allowed to identify quantities of several B vitamins, especially folates and C vitamins, high protein value and source of dietary fiber with a low lipid content (BREENE, 1990).

In a study that examined vegan diets performed in conjunction with food supplementation of wild mushrooms, it was also found that the intake of dehydrated mushrooms can contribute positively to the supply of important nutrients to the body, such as vitamin D (SCHWARZ *et al.*, 2014).

Regarding the amount of micronutrients present in mushrooms, it is important to note that there are several factors, to which mushrooms are exposed in their production process, which are determinants of their vitamin concentrations, causing the percentages of micronutrients to vary from species to species, type of substrate used, its degree of maturation, modes of storage and conservation. The same is observed in relation to variations in macronutrients between species (Furlani, 2004).

Demonstrations made regarding the vitamin content present in the mushrooms show that this variation of micronutrients depends both on the species of the mushroom, as well as on its source, which gives each species a different performance in the levels of antioxidant activity. For the case of variation in tocopherol levels, for example, in the species F. Velutipes, the levels of tocopherols (α-tocopherol, β-tocopherol and δ-tocopherol, but not γ-tocopherol) (0.6 µg / g) were found dry weight), ascorbic acid (238 µg / g dry weight), β-carotene (3.4 µg / g dry weight) and lycopene (0.2 µg / g dry weight) (BREENE, 1990; PEREIRA *et al.*, 2012).

In phenolic extracts obtained from the species L. edodes, antioxidant and antimicrobial activities were identified, in addition to the presence of fumaric acid, in which the potential of their microbial agents to inhibit S. enteritidis, S. aureus, B. cereus and E strains was observed coli. Thus, the presence of biologically active agents that are extracted by non-toxic

solvent in L. edodes shows its high antioxidant and natural antimicrobial capacity, which makes it an excellent option for commercialization through the food or pharmaceutical industry (BACH, 2017).

Clinical studies suggest the benefits of mushrooms in various functions of the body. These introductory data provide evidence that mushrooms can support healthy immune and inflammatory responses through interaction with human intestinal microbiota, improving the development of adaptive immunity and immune cell functionality. In addition to the direct nutritional and health benefits, analysis of data from the US food intake survey reveals that mushrooms offer higher food quality (FEENEY, 2014).

Edible mushrooms are a good source of vitamins C, B1, B2, niacin and biotin and are also related to antioxidant properties due to their bioactive compounds, such as polyphenols, carotenoids and minerals (BREENE, 1990; KOZARSKI, 2015).

Polyphenols are compounds that can be classified into different groups according to the number of phenolic rings and exert their antioxidant effect by extinguishing free radical species and / or promoting endogenous antioxidant capacity, in addition, they can improve cell survival as pro-oxidizing agents, where they can induce apoptosis and prevent the growth of tumors, and fight bacterial and viral infections (KOZARSKI, 2015).

Flavonoids are compounds often found in nature in the form of glycosylate or esterified conjugates, but they can also occur as aglycone in food. It is generally considered that the primary mechanism of free radical scavenging activity is the donation of hydrogen atoms, which is caused by the presence and position of the various hydroxyl groups in its structure (KOZARSKI, 2015).

3.3 Bioactive and nutraceutical characteristics of mushrooms in body aesthetic

There is a variety of edible mushrooms, in which they have important nutritional and functional properties, thus favoring a

healthy diet.

According to Bach (2017, p. 22) "the functional benefits are linked to the presence of compounds with biologically active properties, such as phenolic compounds, polysaccharides, glycoproteins, terpenes and steroids". According to Angelo (2007), phenolic compounds are chemical structures that have hydroxyls and aromatic rings, in simple or polymer forms, which have the antioxidant power, that is, they fight the imbalance between the amount of free radicals. The main groups of phenolic compounds are flavonoids, phenolic acids, tannins, stilbenes and lignans, with phenolic acids and flavonoids being the most common among edible mushrooms (BACH, 2017).

According to Terpinc et al. (2011) phenolic acids represent a significant portion of polyphenols in our diet and their bioactivity (antioxidant properties) is related to phenolic hydroxyl groups linked to ring structures, which can act as reducing agents, hydrogen donors, singlet oxygen inhibitors, superoxide radical scavengers and as metal chelators on hydroxyl and peroxyl radicals, superoxide anions and peroxynitrites (*apud* HELENO, 2015).

Flavonoids are bioactive compounds that constitute one of the largest phenolic groups in plants and mushrooms (SANTOS; RODRIGUES, 2017). The chemical structure of flavonoids consists of two aromatic rings, joined by three carbons, usually in the form of a heterocyclic ring (BACH, 2017). Studies have pointed out that the consumption of foods rich in flavonoids is related to reducing the risk of various diseases, the protective effect of these foods is due to their antioxidant properties and their ability to reduce oxidative stress (SILVA *et al*., 2016).

Polysaccharides are the soluble fraction of dietary fibers in mushrooms known to have biological activity (BACH, 2017). According to Leódido *et al.* (2017) are carbohydrates composed of a large number of monosaccharide molecules, found in all living organisms, from bacteria to more complex beings. Its biological activities have been highlighted by their immunological effects on inflammatory actions, activating or

canceling the responses of cells in the immune system (LEÓDIDO *et al.*, 2017).

Hudes (2000, *apud* FERREIRA, 2014) says that terpenes (secondary metabolites of plant origin) represent the oldest group of small molecule products synthesized by plants and probably the most widespread group of natural products. These hydrocarbons are classified according to the number of isoprene units, being: hemiterpenes, monoterpenes, sesquiterpenes, diterpenes and polyiterpenes (MCGARVEY; CROTEAU, 1995 *apud* FERREIRA, 2014). Sesquiterpenes and monoterpenes are present in several essential oils, such as: menthol, linalool, citral, α-humulene, β-karyophylene, among others (FERREIRA, 2014), covering several therapeutic properties.

4 Final Considerations

Mushrooms are rich in proteins with good bioavailability, low lipid content and an excellent source of fibers with nutraceutical capabilities, derived from their bioactive compounds, polyphenols and other biologically active compounds that have an action on body aesthetics.

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