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Mushrooms extracts and compounds in cosmetics, cosmeceuticals and nutricosmetics—A review

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ABSTRACT

The cosmetic industry is constantly in search of ingredients from natural sources because of their competitive effectiveness and lower toxicity effects. Mushrooms have been an important part of our diet for years and are now finding their way as cosmetic ingredients, either as cosmeceutical or as nutricosmetics. The present review focuses on the most relevant activities of mushroom extracts, as well as on their bioactive compounds, which make them interesting ingredients for cosmetic formulations. Mushroom extracts, as well as their bioactive metabolites, revealed anti-tyrosinase, anti-hyaluronidase, anti-collagenase and anti-elastase activity. Emphasis was also given to their important anti-oxidant, antimicrobial and anti-inflammatory potential, topics largely studied by numerous authors, making them very versatile and multi-functional cosmetic ingredients. Some of the bioactive compounds and the mechanism responsible for the activities ascribed to mushrooms were highlighted. Other activities were identified as needing to be further studied in order to identify the major compounds contributing to the target activity, as well as their mechanisms of action. Based on the above findings, mushroom extracts, as well as their bioactive metabolites, constitute important ingredients that can help to combat aging, reduce the severity of inflammatory skin disease and correct hyperpigmentation disorders. These findings and claims must be correctly supported by clinical trials and *in vivo* studies.

Contents

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1. Cosmetics, cosmeceuticals and nutricosmetics

A "cosmetic product" is any substance with soft action that is either rubbed or sprinkled on the various parts of the human body with the sole aim to clean, beautify, increase the attractiveness, protect them and keeping them in good condition (Luque de Castro, 2011). The world's cosmetic industry is worth tens of billions of US dollars, and is in a constant search for new and improved natural products to serve as suitable raw-materials, able to compete with the artificial synthetic counterparts or add new bioactivities. In Asia, mushrooms have been used as medicinal ingredients for thousands of years and in China and Japan for example, they were kept in reserve for royalty because of their potency and efficacy (Hyde et al., 2010).

Cosmeceuticals can be defined as the combination of cosmetics and pharmaceuticals. They consist of products which are applied topically and comprise creams, lotions and ointments with biologically active compounds with medical drug-like benefits (Sharma, 2011). These products are known to contain ingredients that influence the biological function of the skin by supplying the needed nutrients for healthy skin while improving the appearance, the radiance, texture and anti-ageing activity (Hyde et al., 2010). The application of natural ingredients such as phytonutrients, microbial metabolites, dairy products (Haruta-Ono et al., 2012; Keller et al., 2014), minerals and animal protein components (Rodrigues et al., 2015) for skin care is very popular today. Extracts of coconut, jasmine, lemon grass, longan and several medicinal plants have been known to play an important role in the treatment of various skin diseases; being for this reason extensively studied and used in many countries around the world, including Africa (De Wet et al., 2013), where they play an important role in skin health care. Fungi, especially mushrooms and their products, are now finding their way into cosmetics and used extensively as crude material or as pure compounds for treating various diseases usually associated with the skin (Hyde et al., 2010).

Nutricosmetics are the newest trend in skin care and involve combining food, cosmetic and pharmaceutical being still unknown to some dermatologists and consumers. This involves the consumption of dietary and nutritional supplements to produce a visual appearance benefit and improve the health of the skin (Luque de Castro, 2011). The focused primary action areas are: skin, hair and well being. Many micronutrients can provide these effects (e.g. vitamin C has an antioxidant potential and tends to reduce free radicals generation when the skin is exposed to UV radiation). Following these trends, cosmetic industries are now putting more efforts to develop nutricosmetics with high contents of several ingredients, such as collagen, hyaluronic acid, elastin and ceramide, known to maintain skin structure and function (Haruta-Ono et al., 2012). These authors reported that oral ingestion of dietary products improves the water-holding capacity of the skin and the barrier function. Hong et al. (2014) also reported the beneficial effect of green tea ingestion due to the presence of numerous phenolic compounds responsible for significant inhibition of enzymes such as collagenase, elastase and tyrosinase, thereby maintaining the structural stability, elasticity and blocking melanogenesis, respectively.

2. Skin aging

The skin is the largest organ of the body, accounting for about 15% of the whole weight. It acts as a barrier against physical, chemical and biologic attacks, while it prevents water loss from the body (Kendall and Nicolaou, 2013). Skin aging is known to be caused by an intrinsic, natural or cellular mechanism that affects not only the skin but also other organs of the body due to changes in hormonal secretion occurring with age, which often result in collagen degradation, dryness, degeneration of elastic fibre networks, and development of laxative and wrinkle skin (Papakonstantinou et al., 2012). The extrinsic mechanism results from the exposure to external factors, mainly over exposure to solar radiation often known as photo aging. Reactive oxygen species (ROS), arising from oxidative cell metabolism causes damage to cellular components like cell walls, lipid membranes, mitochondria, and DNA, playing a major role in both processes. It induces activator protein-1 (AP-1), a transcription factor that promotes collagen breakdown by up regulating enzymes called matrix metalloproteinases (MMPs). Overexpression of matrix metalloproteinase (MMP-1, MMP-3 and MMP-9) leads to elevated levels of degraded collagen (Leem, 2015). Also, UV radiation causes downregulation of transforming growth factor β (TGF-β), a cytokine that promotes pro-collagen production thus causing reduced collagen synthesis (Fig. 1). Even though elastin and collagen are the main components of the extracellular matrix, it also contains hyaluronic acid, a key molecule which is responsible for moisturizing the skin and making it less prone to oxidative stress (Papakonstantinou et al., 2012).

Therefore, the inhibitors of elastase, hyaluronidase, tyrosinase and MMP-1 enzymes can be potential cosmetic ingredients in the treatment of skin aging thereby restoring the skin elasticity, increase moisture content, stimulate collagen synthesis and skin lightening effect. Hence, cosmetic industry is searching for natural compounds, supplements or extracts with the ability to delay the aging process. Natural phenolic compounds have been reported to possess scavenging properties against ROS making them interesting candidates for production of antiaging creams or lotions in the cosmetic industry (Soto et al., 2015).

3. Mushroom extracts and individual compounds as cosmetic ingredients

Mushrooms are an important part of our diet and have been consumed for years because of their nutritional composition, taste and flavour. They have been extensively studied and several research publications have reported the presence of a wide range of bioactive metabolites, e.g. phenolic compounds, terpenoids, polysaccharides, lectins, steroids, glycoproteins and several lipid components. Several mushroom extracts, as well as their secondary metabolites, have been reported to display important biological functions such as antioxidant, antitumor, antimicrobial, anti-inflammatory, immunomodulator, antiatherogenic, and hypoglycemic activities (Ferreira et al., 2009, 2010; Alves et al., 2012; Taofiq et al., 2016). On the contrary, only very few studies have been reported for the anti-tyrosinase, anti-collagenase, anti-elastase and anti-hyaluronidase activities of mushroom extracts and individual compounds (References cited in Tables 1 and 2, respectively). Even less explored, these studies and the discussed bioctivities, lead to dermatologists and researchers with interest in cosmetics to be optimistic about the future of mushrooms and their compounds in the cosmetic industry.

3.1. Antioxidant activity

Several biological reactions, required for normal functioning of the organism, take place in body cells and tissues. These reactions often cause generation of species with unpaired electrons called free radicals. These free radicals include ROS, reactive nitrogen species (RNS) and reactive sulphur species (RSS). The body usually has mechanisms to balance ROS production and neutralization by means of its intrinsic antioxidant pool (glutathione peroxidase, catalase and superoxide dismutase), but most of the times it can become depleted due to excessive ROS production allowing the body cells to suffer from oxidative stress (Carocho and Ferreira,