Studies on biochemical constituents of mycelium and fruiting bodies of reishi mushroom (Ganoderma spp.)

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Abstract

The present investigation was conducted at the Mushroom Research Laboratory (AICRP on Mushroom), Department of Plant Pathology, Department of Medicinal and Aromatic Plant Science, Department of Biotechnology and Department of Soil Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur. The mycelium and fruit body of G. lucidum was found to be more superior than G. applanatum with respect to protein, moisture, fat, carbohydrates and mineral contents. The protein, fat, carbohydrate and moisture in different Ganoderma spp. ranged from 8-12%, 1-2%, 51-57% and 7-12%. The mycelium and fruit bodies of different strains and species of Ganoderma spp. was found to be rich in potassium, phosphorus, zinc and manganese while other minerals were also present in good quantities.

Keywords: Ganoderma applanatum, G. lucidum, protein, fat carbohydrate, minerals, moisture

Introduction

Most of the food groups for human consumption are either of plant origin or animal origin. Mushroom is a rare type which can be eaten as often as possible with no side effect. Some mushrooms possess pharmacological properties. They usher wellness with minimum adverse effects. There is however a wide scope to screen other mushrooms both wild and cultivated for their medical attributes. The medicinal mushroom genus Ganoderma is established by Karsten (1881) [7] with Ganoderma lucidum (Curtis) P. Karst. as the type species (Moncalvo and Ryvarden, 1997) [11]. Ganoderma lucidum is an important mushroom due to presence of various bioactive chemical constituents which reflects various biological properties and are generally used as a cure for various diseases, as health tonics, cosmetics etc. In ancient China and Traditional Chinese Medicine (TCM), Ganoderma was believed to replenish the energy, ease the mind, and relieve cough and asthma (Wachtel-Galor et al. 2011) [19]. Ganoderma lucidum is used in daily life food products like soup, tea, wine and yoghurt (Dong and Han, 2015) [10]. It is used with ginseng (Panax ginseng) to make soups which is used in soothing nerves, strengthening immune system and treating asthma; with Panax nostogiinseng to make herbal Sanqi wine which is used in promoting blood circulation and soothing nerves (Zhao, 2015). Since old occasions, mushrooms were highly regarded as ‘food of gods’, ‘delicacy food’ and ‘solidarity to warriors’ by Romans, Pharaohs and Greeks respectively (Daba et al. 2008) [3]. Various researches have proved the therapeutic properties of this mushroom. More than 20 medicinal mushrooms are being produced and marketed at present. Value wise most important ones are Ganoderma lucidum, Cordyceps sinensis, Lentinula edodes, Hericium erinaceus, Schizophyllum commune (Thakur 2020) [17].

Mushrooms are esteemed for their sensory, nutritional and therapeutic properties as well as their mineral nutrients composition (Kuldo et al., 2014 and Wang et al., 2014) [19, 18]. They are important owing to higher proteins, vitamins and mineral levels and lower levels of fat and calories (Genccelep et al., 2009) [3]. Fruiting bodies of mushrooms are esteemed for taste and flavor and are also consumed as fresh and processed forms (Zahid et al., 2010) [23]. The Ganoderma mushroom contains about 90% water and 10% of the dry matter. It is rich in protein (10-40%), fat (2-8%), carbohydrate (3-28%), fiber (3-32%) and ash (8-10%),...
minerals like calcium, minerals, phosphorus, potassium, copper, iron, zinc, magnesium and selenium on wet weight basis (Zhou et al., 2007) [21]. More than 400 bioactive compounds like- polysaccharides, triterpenoid, nucleotides, steroids, fatty acids and other trace elements have been isolated and identified from its fruiting body, spores and mycelia. These ingredients have various pharmacological properties like anti-bacterial, anti-viral, anti-tumour, immunomodulation, sleep promotion, anti-ageing, anti-ulcer etc. (Sanodiya et al., 2009) [13]. An attempt for therefore made to study the biochemical constituents present in the mycelium and fruiting bodies of different species of Ganoderma spp., a magic mushroom.

Materials and Methods
Estimation of biochemical constituents of mycelium and basidiocarp

**Estimation of Moisture:** Weighed the sample accurately and placed in an oven at 60°C for 24 hrs. Weighed the oven-dried sample and again dried in an oven in same way, till the constant weight was obtained. The percentage of moisture was estimated by subtracting the final dried weight from the initial weight of sample.

\[ \text{Moisture} (\%) = \frac{\text{Weight loss}}{\text{weight of sample}} \times 100 \]

**Estimation of fat:** Fat was estimated as per the method given by Sadasivam and Manikam (1992) [14] using “ Soxhlet apparatus”. The fat content was calculated using following formula:

\[ \text{Fat content} = \frac{\text{Wt. of flask with fat} - \text{Wt. of empty flask}}{\text{Wt. of flask}} \times 100 \]

**Estimation of total protein content:** Nitrogen content was determined by micro-kjeldhal method according to AOAC (1980) [1] procedure using Gerhardt Digestion and Distillation (Model VAP-30), West Germany. The estimated nitrogen was converted into protein by multiplying protein factor of 6.25 (N x 6.25). In each case, defatted sample was taken for estimation.

**Determination of carbohydrate:** 0.1 g extracted oven dried sample was taken in to 10 ml test tube and 5 ml of 2.5 N HCl was added.Kept in water bath for 3 hrs. After 3 hrs, cooled and neutralized with Na2CO3 till the fan not stop. Made up the volume to 100 ml by adding distilled water. Pipetted out 10 ml of above solution in test tube and centrifuged it for 10-15 minutes at 4000 rpm. Also set a blank with distilled water. Pipetted out 0.1 ml extract from test tube in another 10 ml test tube and added 1.9 ml distilled water to make 2 ml volumes.In 2 ml volume, added 4 ml anthrone reagent and kept it on water bath for 8 min. at 100°C temperature. Cooled and observed reading at 630 nm on spectrophotometer.

Carbohydrate content (g/100g) = 131.06 x OD x 100/0.1 x 1/0.1 x 1/1000 x 100/1000

**Estimation of Minerals:** The potassium was determined by flame photometer while phosphorus was determined by Spectrophotometer as described by Jackson (1958). Zinc, iron and manganese were estimated by an atomic absorption method as per procedure of AOAC (1980) [1].

Results and Discussion
Nutritional composition of fruit body and mycelium of Ganoderma spp.
The fruit body and mycelium of Ganoderma strains were analyzed for nutritional constituents and the results obtained are presented in Table 1 & 2. It was found that the fruit body and mycelium of different strains of Ganoderma differed significantly in fat, protein, carbohydrate and moisture content (Table 1). The fat content was significantly higher (2.24%) in fruit body of G. lucidum (Udaipur strain) followed by fruit body of G. applanatum (2.0%) whereas, very less fat (1.47%) was observed in the mycelium of local strain of Ganoderma. Higher protein content (11.28%) was observed in the fruit body of local strain of Ganoderma. Fruit body of G. applanatum and G. lucidum showed 10.63 and 10.42 percent protein. The mycelium of G. applanatum and G. lucidum (IS) and local strain of Ganoderma showed 10.22, 9.68 and 8.94 percent protein. The carbohydrate content was higher (57.26 percent) in mycelium of G. applanatum followed by mycelium of G. lucidum (IS) (57%). In mycelium and fruit body of local strain of Ganoderma, 55.17 and 53.51 percent of carbohydrates respectively was found. Lower carbohydrates content (51.70%) was observed in fruit body of G. lucidum. The mycelium of G. lucidum (IS) contains higher moisture (12.70%). Fruit body and mycelium of G. applanatum contains 10.33 and 10.61 per cent moisture respectively whereas, fruit body of G. lucidum contains 11.31 per cent moisture. In fruit body and mycelium of local strain of Ganoderma, moisture content was lower (7.67 and 7.41 %). Thus, it can be said that the mycelium and fruit body of G. lucidum was richer in fat, protein, carbohydrates and moisture compared to that of G. applanatum. It was observed that the mycelium of Ganoderma spp. had significantly more carbohydrate (56.47%) compared to that of fruitbodies of Ganoderma spp. (52.66%). On the contrary, fruit bodies of Ganoderma spp. had significantly higher protein (10.77%) compared to that of mycelium of Ganoderma spp. (9.61%). The difference in fat and moisture content of mycelium and fruit bodies of Ganoderma spp. is non significant. The fat content of edible mushrooms consists mostly of unsaturated fatty acids, which are less hazardous to the health than the saturated fatty acids of animal fats (Zahid et al., 2010) [23]. Almost similar chemical composition of about 90% moisture and 10% of the dry matter in Ganoderma spp. was reported by Zhou et al., 2007 [21]. They found that the fruit bodies were rich in protein (10-40%), fat (2-8%), carbohydrate (3-28%), fiber (3-32%) and ash (8-10%) on wet weight basis. Wasser and Weis (1999) [20] reported lesser protein (5%) and polysaccharides (51%) in Ganoderma lucidum. Eo et al. (1999) [4] reported 7.8 per cent protein in G. lucidum whereas Patra and Tripathi (2006) [12] found 8-12% protein, 1.9 % fat and 54-59% carbohydrates in Ganoderma spp. which were in accordance with the present results. Sharif et al., (2016) [16] reported higher content of protein (15.04%), higher carbohydrate (82.47%) but less fat (0.53%) in the fruimbodies of Ganoderma lucidum.
Table 1: Nutritional composition of mycelium and fruit body of different strains of Ganoderma spp.

| Strains/parts of Ganoderma spp. | Fat (%) | Protein (%) | Carbohydrates (%) | Moisture (%) |
|---------------------------------|---------|-------------|--------------------|--------------|
| Mycelium of local strain of G. lucidum | 1.47    | 8.94        | 55.17              | 7.41         |
| Mycelium of G. lucidum (IS) | 1.55    | 9.68        | 57.00              | 12.70        |
| Mycelium of G. applanatum | 1.68    | 10.22       | 57.26              | 10.61        |
| Fruit body of local strain of G. lucidum | 1.49    | 11.28       | 53.51              | 7.67         |
| Fruit body of G. lucidum (IS) | 2.24    | 10.42       | 51.70              | 11.31        |
| Fruit body of G. applanatum | 2.00    | 10.63       | 52.79              | 10.33        |
| F value |            | S           | S                  | S            |
| SEm±   | 0.162    | 0.06        | 0.288              | 0.17         |
| CD (0.05) | 0.50    | 0.19        | 0.89               | 0.53         |

Different strains and species of Ganoderma were found to be rich in different minerals (Table 2). The mycelium and fruiting body of G. lucidum was richer in phosphorus, potassium and zinc as compared to G. applanatum. Higher amount of phosphorus (0.241%) and potassium (0.89%) was found in mycelium of local strain of Ganoderma and mycelium of G. lucidum (IS) whereas lowest amount of phosphorus (0.152) was obtained in mycelium of G. lucidum (IS) and potassium in fruit body of G. applanatum (0.68%). The fruit body of G. applanatum contained higher amount of iron (0.058 ppm) and manganese (0.027 ppm), whereas zinc was maximum in mycelium of G. lucidum (IS, 0.081 ppm). The fruit body of G. lucidum contained lower amount of Iron (0.013 ppm) and zinc (0.011 ppm) whereas, lower amount of manganese (0.016 ppm) was found in mycelium of G. applanatum. Thus, it can be said that the mycelium and fruiting body both of G. lucidum are richer in phosphorus, potassium and zinc compared to G. applanatum which is highly desired by the human body. The essential macronutrient minerals are sodium, potassium, magnesium and calcium. The functions of macronutrient minerals are to maintain acid-base balance, the osmotic regulation of fluid and oxygen transport in the body (McDowell, 2003) [10]. The known essential micronutrient minerals are iron, zinc, selenium, manganese, cobalt and copper. These micronutrients play an important role in the catalytic processes within the enzyme system that includes a wide range of enzyme activities associated with metabolic, endocrine and immune systems (Keen et al., 2004) [8]. Living organisms require traces of some heavy metals, including iron, cobalt, copper, manganese, chromium and zinc. Excessive levels of these metals, however, can be detrimental to human health. Roy et al. (2015) [16] reported higher content of phosphorus, potassium and zinc in the Ganoderma lucidum compared to that of oyster mushroom (Pleurotus ostreatus). The present findings are also in agreement with the results of Sharif et al. (2016) [10] who observed more content of phosphorus, potassium and zinc in the Ganoderma lucidum. Wasser and Weis (1999) [20] and Patra and Tripathi (2006) [12] also reported good amount of Mg, Mo, Ca, Zn, K, Na, Fe, Cu, Mn, Zn in the Ganoderma fruit body.

Table 2: Estimation of mineral content in different Ganoderma spp.

| Treatments | Phosphorus (%) | Potassium (%) | Iron (ppm) | Manganese (ppm) | Zinc (ppm) |
|------------|----------------|---------------|------------|-----------------|------------|
| Mycelium of local strain of G. lucidum | 0.241 | 0.77 | 0.032 | 0.021 | 0.043 |
| Mycelium of G. lucidum (IS) | 0.152 | 0.89 | 0.014 | 0.023 | 0.081 |
| Mycelium of G. applanatum | 0.180 | 0.87 | 0.014 | 0.016 | 0.021 |
| Fruit body of local strain of G. lucidum | 0.229 | 0.79 | 0.033 | 0.022 | 0.022 |
| Fruit body of G. lucidum | 0.190 | 0.87 | 0.013 | 0.022 | 0.011 |
| Fruit body of G. applanatum | 0.233 | 0.68 | 0.058 | 0.027 | 0.014 |
| F value |            | S           | S          | S               | S           |
| SEm±   | 0.0114    | 0.0092     | 0.0020     | 0.0015         | 0.0014     |
| CD (0.05) | 0.04    | 0.03        | 0.01       | 0.0081         | 0.0075     |

Conclusions
Mushroom species grow and fruits well on a wide varieties of agrowastes consisting of cellulose, hemicellulose and lignin. Growing medicinal or other edible mushrooms on lignocellulosic wastes represent the most successful example of solid state fermentation to generate an easier separation of valid and valued form of biomass represented by the mushrooms. Mushroom consisting of mycelium and fruiting body are rich in several essentials macro elements, anti oxidants and micro nutrients imparting various health effects in activating human immune system. Higher protein content was observed in the fruit body of local strain of Ganoderma spp. in the present study. Higher fat percentage was observed in the fruit body G. applanatum. Carbohydrate content was significantly higher in the mycelium of G. lucidum and G. applanatum whereas protein was significantly more in the fruitbodies of Ganoderma spp. compared to that of mycelium. On the contrary, moisture and fat content did not vary much in the mycelium and fruit bodies of G. lucidum and G. applanatum. The mycelium and fruit bodies of different strains and species of Ganoderma were richer in potassium, phosphorus, zinc and manganese content. Thus, the future of mushroom as health food looks brighter, befitting the health needs of modern lifestyle but demands concerted efforts, perseverance and precision.

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