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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 not a member of either. It is a member of fungal kingdom. Mushroom is one of the rare food type which can be eaten as often as possible with no side effect. Some mushrooms possess pharmacological properties. They usher wellness with minimum adversaries. 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 cure of 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 yoghourt (Dong and Han, 2015) [3]. It is used with ginseng (*Panax ginseng*) to make soups which is used in soothing nerves, strengthening immune system and treating asthma; with *Panax nostoginseng* 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) [2]. 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 edodus*, *Hericium erinaceous*, *Schizophyllum commune* (Thakur 2020) [17]. Mushrooms are valued and appreciated for their sensory, nutritional and therapeutic properties as well as their mineral nutrients composition (Kuldo *et al*., 2014 and Wang *et al*., 2014) [9, 18]. They are important owing to higher proteins, vitamins and mineral levels and lower levels of fat and calories (Genccelep *et al*., 2009) [5]. 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) [15]. 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.

Moisture (%) = Weight loss / weight of sample x 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:

Fat content = Wt. of flask with fat- Wt. of empty flask.

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 Na_2CO_3 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 fruibodies 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 *Ganoderma lucidum*	1.47	8.94	55.17	7.41
Mycelium of *Ganoderma lucidum* (IS)	1.55	9.68	57.00	12.70
Mycelium of *Ganoderma applanatum*	1.68	10.22	57.26	10.61
Fruit body of local strain of *Ganoderma lucidum*	1.49	11.28	53.51	7.67
Fruit body of *Ganoderma lucidum* (IS)	2.24	10.42	51.70	11.31
Fruit body of *Ganoderma applanatum*	2.00	10.63	52.79	10.33
F value	S	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. appanatum*. 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 microminerals 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) [13] 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) [16] 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 *Ganoderma lucidum*	0.241	0.77	0.032	0.021	0.043
Mycelium of *Ganoderma lucidum* (IS)	0.152	0.89	0.014	0.023	0.081
Mycelium of *Ganoderma applanatum*	0.180	0.87	0.014	0.016	0.021
Fruit body of local strain of *Ganoderma lucidum*	0.229	0.79	0.033	0.022	0.022
Fruit body of *Ganoderma lucidum*	0.190	0.87	0.013	0.022	0.011
Fruit body of *Ganoderma applanatum*	0.233	0.68	0.058	0.027	0.014
F value	S	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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