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Proximate analysis, mineral and germanium of *Ganoderma lucidum* or Lingzhi powder by spray dry affecting in different strains and their maltodextrin

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Abstract *Ganoderma lucidum* or Lingzhi powder has been used for food and beverage ingredients for nutrition and health promoting. The *G. lucidum* in difference strains of MG2 and G2 were investigated to be good quality powder. The dried lingzhi was ground and stored in an air tight black polythene bag at room temperature until used. Commercial water extraction (100°C in 76 min) and spray drying (inlet temperature 140°C and outlet temperature 80°C) were operated to produce lingzhi powder from. *G. lucidum* MG2 and G2 extracts, and then spray drying with and without maltodextrin to make lingzhi powder. It was found that strains of lingzhi and maltodextrin affected to proximate constituent mineral and germanium of lingzhi powder. From the analysis of *G. lucidum* MG2 and G2 powder through spray drying found that the nutritional value as a good source of energy carbohydrate, protein and minerals. Results showed that germanium from *G. lucidum* powder from starin MG2 higher than strain G2.

Keywords: *Ganoderma lucidum*, Germanium, Mineral, Proximate analysis, Spray dry

Introduction

Ganoderma lucidum or Lingzhi become more popular as a source of nutrients and highly bioactive secondary metabolites. In East Asian countries, *G. lucidum* is utilized as an elicitor of life to enhance health and longevity. Bioactive triterpene, polysaccharide, and protein components are presented in the extract of *Ganoderma* which is unique to consume for its pharmaceutical value rather than as a food (Jeewanthi *et al*., 2017). *G. lucidum'*s compounds have been examined for their possible immunomodulating activity, blood glucose regulation, antibacterial, antiviral, anticancer, and antioxidant properties, antiviral effects which is established in both *in vitro* and in animal settings (Ahmad, 2018). Since in ancient times, *G. Lucidum* is a medicinal

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macrofungi which has been praised in the orient (Sanodiya *et al*., 2009). Fruiting bodies of *G. Lucidum* as well as mycelia, and spores are reported to be bioacticvely treated to chronic hepatitis, hypertension, and hyperglycemia. *G. lucidum* is a large, dark and sculptured structure with a varnish appearance and woody texture (Bao *et al,* 2002). The nutritional and therapeutic benefits of *G. lucidum*, as well as the mineral components composition, are regarded and appreciated (Sharif *et al.,* 2016). Lingzhi are praised for their nutritional and medicinal qualities mineral components. (Kuldo *et al*., 2014). They are importantly included in higher proteins, vitamins, and minerals while containing less fat and calories (Genccelep *et al*., 2009). *Ganoderma* species lack a fleshy texture and are not classified as edible due to their thick, rigid, and corky fruiting bodies. Although *Ganoderma* species are not eating directly, they are well recognized as highly medicinal all over the world (Jonathan and Awotona, 2010). (Nguyen *et al*.,2019). reported that *G. lucidum* extracts contain carbohydrates, glycosides, triterpenoids and phenolic compounds, alkaloids, proteins, coumarin, flavonoid, phenols, lignocellulose degrading enzymes. It is also believed to be anti-hypertensive and anti-diabetic properties, and microbiological activity against *Aspergillus niger*, *Bacillus cereus*, *Candida albicans,* and *Escherichia coli*. *G. lucidum* was also claimed to be antiviral activity. It was also stated that *G. lucidum* expressed anti-tumor, antibacterial capabilities, anti-inflammatory, antimicrobial, hepato-protective, hypotensive, anti-diabetic, antioxidant, modulation of the immune system and bacteriostasis (Kuldo *et al.,* 2014; Liu *et al.,* 2009).

Lingzhi is well-known for its ability to accumulate a wide range of metals and metalloids in fruiting bodies, including importantly health for human nutrition. Lingzhi come from a wide range of geographical areas. The majority of these investigations reported that germanium (Ge) levels below detection limits, but some discovered it at levels ranging from a few micrograms per kilogram in *Phellinus* sp. and approximately 1 milligram per kilogram in *Ganoderma* sp. (Siwulski *et al.,* 2017). Germanium has a wide range of biological effects, including antibacterial, antiviral, anti-inflammatory, anticancer, antitumor properties, free radical elimination, cell aging prevention, and immune control (Li, *et al*, 2017). Ge levels in the fruiting bodies of *Ganoderma* is shown to be high amount (Chiu *et al*., 2000). However, little is known about the kinetics of Ge uptake and accumulation in Lingzhi, as well as their growth, morphology, nutritional value, and biological activity. Ge was used to create new dietary supplements and therapeutics by (Ferro *et al*., 2019).

Spray drying is a method of producing a dry powder from a liquid or slurry by rapidly drying with hot temperature. It is preferred as a drying method of many thermally sensitive materials such as foods and pharmaceuticals, Spray drying is mostly used to be the method in the food sector due to its low cost and simplicity operation. Despite, the short drying contact time (a few seconds) of the core materials in the drying chamber, spray dryers have known to be high drying temperatures, typically between 150 and 250 ℃ at the air temperature and 50–80 ℃ at the outlet air temperature (Geranpour *et al*., 2020). *G. lucidum* products are available in a variety of forms, including powder, nutritional supplements, tea, syrup, cream, and hair tonic. They are also available in capsule or tablet form after being powdered (Nguyen *et al.*, 2019). Additional research is needed to elucidate the health benefits of this fungus, particularly for the demand of food and nutrition-conscious population. The objectives were to complete proximate analysis, mineral analysis, and germanium analysis on the *G. lucidum* powder differences between strains of MG2 and G2.

Materials and methods

G. lucidum strains MG2 and G2 were used in this study. *G. lucidum* MG2 obtained from a local market in Chiang Mai, Thailand, and *G. lucidum* G2 imported from China. The dried lingzhi was ground to a 4 mm. using a cutting mill and an ultra centrifugal mill, and then stored at room temperature in an airtight black polythene bag until used.

G. lucidum powder preparation was done by using ground *G. lucidum* at a ratio of 20 kg per 1000 kg of water in a commercial water extraction (high speed extractor), and temperatures were maintained at 100°C for 76 minutes. The extracted solution was filtered via a falling film evaporator model (VPF-200L) at 60°C until it was completely dried. *G. lucidum* MG2 and G2 were extracted and evaporated, followed by spray dry using spray drier model SDG-100 NF inlet temperature 140°C and outlet temperature was 80°C with and without maltodextrin to produce *G. lucidum* powder.

The proximate nutritional analysis of *G. lucidum* powder was carried out using the methods from the Association of the Official Analytical Chemist (AOAC 1995). Moisture content was established by drying 2g of test sample at 105 ℃ for 16 hours in a hot air oven (UM500, Memmret). The ash content was measured by combusting 2g of *G. lucidum* powder in an electric furnace at 505 ℃ for two hours. The protein content was estimated by the Kjeldahl method which the protein content was estimated by multiplying by a conversion factor of N × 4.38 (Fujihara *et al.* 1995). Lipids were determined by the Soxtec 20055 Extraction unit (Foss Tecator) with petroleum ether. The total carbohydrate and energy value were calculated according to the following equations Carbohydrate (%) = 100 - (g moisture + g ash + g lipid + g protein + g fiber)

(Rizal *et al*., 2015). Energy (kJ) = 3.25 × (g protein) + 4.2 × (g carbohydrate) + 9.10 × (g fat) respectively (Kumari and Atri 2014). All experiments were carried out in triplicate. The energy was calculated according to the following equation: Energy (kcal)=4 × (g protein+g carbohydrate) +9 × (g fat) (Leal *et al*., 2013).

Mineral Analysis was done by inductively coupled plasma-optical emission spectrometer (ICP-OES) to measure potassium (K), phosphorus (P), magnesium (Mg), calcium (Ca), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), and germanium (Ge). The concentrations were corresponded to three times in the standard deviation of ten blanks which is called the detection limit. The ICP-OES was calibrated using a commercially provided working standard. Measurements were taken within the linear range of working standards used for calibration, using the most appropriated wave length, argon gas flow, plasma stabilization, and other ICP-OES parameters for metals/minerals. The following were done by working conditions at ICP-OES: ICP-OES as the instrument used in this study (Perklin Elmer, optima 4300Dv, USA), 40 MHZ (Megahertz), free running solid state RF generator, 15 L/min plasma gas flow at 0.8 L/min auxiliary gas flow for 3 seconds in reading time. All mineral concentrations were measured in milligrams per 100 g of dry sample weight (Mallikarjuna *et al*., 2013).

Statistical analysis was used SPSS V.26 software to analyze data, and results were expressed as mean ±SEM. Oneway Analysis of Variance (ANOVA) and Least Significance Difference (LSD) tests were utilized to decide the distinctions among the methods. An estimation of $P \leq 0.05$ was shown to be statistically significant.

Results

Proximate compositions of *Ganoderma lucidum* MG2, G2 were recorded. The chemical composition of moisture, protein, fat, calcium, ash, and energy value calculated the proximate composition values according to the procedure of AOAC (1995). The *Ganoderma* sample consisted of two strains of G. *lucidum* strains MG2 and G2 (Table 1). Carbohydrate content of *G. lucidum* MG2 and G2 maltodextrin added lingzhi on a spray dring is shown in Table1. The difference between *G. lucidum* MG2 and G2 with maltodextrin added during the spray drying process was significantly ($p \leq 0.05$) highest carbohydrate content ranged from 93.96 to 93.12%. *G. lucidum* MG2 had the highest protein composition (28.49%, DW), followed by *G. lucidum* G2 (18.74%, DW) and *G. lucidum* MG2 added maltodextrin (2.30%, DW) and *G. lucidum* MG2 added maltodextrin 1.84%, DW).

A result of the lipid content of lingzhi powder is shown in Table1. The lowest fat level (0.10%, DW) was found in *G. lucidum* G2 with and without maltodextrin, whereas the highest fat content was found in *G. lucidum* MG2 (0.40%%, DW). There was significantly differed (P≤0.05) between *G. lucidum* MG2 and *G. lucidum* G2. Result displayed the ash content in Table 1. The ash level of *G. lucidum* MG2 was highest (29.04%, DW), followed by *G. lucidum* G2 (21.45%, DW). The addition of maltodextrin to *G. lucidum* G2 and MG2 powder resulted in low ash content of 2.38 and 1.62% DW, respectively

Moisture

The moisture content of *G. lucidum* G2 and MG2 powder without added maltodextrin during spray drying process was found to be the highest values of 4.71-4.60%, DW. *G. lucidum* G2 and MG2 with added maltodextrin had a low moisture content of 2.19-2.20% DW. The difference between the samples was statistical significant (P≤0.05).

Calorie

The differences in calorie content between *G. lucidum* MG2 and G2 were significantly differed (P≤0.05) as shown in Table 1. *G. lucidum* MG2 was 3902.4 Kcal/kg and *G. lucidum* was G2 3859.7 Kcal/kg.

Table 1. Proximate analysis of different sources of *G. lucidum* (%dry weight)

Proximate composition	***G.lucidum* MG2**	***G.lucidum* G2**	***G.lucidum* MG2 maltodextrin**	***G.lucidum* G2 maltodextrin**
Carbohydrate	37.42±0.32^{c}	55.11±0.13^{b}	93.96±0.12^{a}	93.12±0.14^{a}
Crude protein	28.49±0.32^{a}	18.74±0.13^{b}	1.84±0.09^{d}	2.30±0.07^{c}
Crude lipid	0.34±0.32^{b}	0.10±0.13^{c}	0.40±0.00^{a}	0.10±0.00^{c}
Ash	29.04±0.05^{a}	21.45±0.02^{b}	1.62+0.06^{c}	2.38±0.11^{d}
Moisture	4.71±0.33^{a}	4.60±0.09^{b}	2.19±0.12^{d}	2.20±0.15^{c}
Calorie (Kcal/kg)	3142.2±0.03^{c}	3427.1±0.13^{b}	3902.4±0.00^{a}	3859.7±0.13^{a}

Mean values with different lower case superscripts (a–c) represented statistically significant difference at 95% level (P ≤ 0.05) with posthoc least significance difference (LSD) test.

The mineral concentrations (mg/100g on a dry weight basis) of *G. lucidum* MG2 and G2 are shown in Table 2. The amount of phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), ferrous (Fe), manganese (Mn), copper (Cu), zinc (Zn), and germanium (Ge) in *G. lucidum* MG2 and G2 were analyzed and it was discovered that the *G. lucidum* MG2 had the highest mineral content in all aspects. Phosphorus (P) 1.94%, potassium (K) 3.66%, magnesium (Mg) 1.02%, calcium (Ca) 1.94%, manganese (Mn) 57.3 ppm, ferrous (Fe) 165 ppm, copper (Cu) 46.7 ppm, zinc (Zn) 112 ppm, and germanium (Ge)18.24 ppm.

Table 2. Nine mineral concentrations of *G. lucidum* MG2 and G2

Minerals	**Unit**	***G.lucidum* MG2**	***G.lucidum* G2**	***G.lucidum* MG2 maltodextrin**	***G.lucidum* G2 maltodextrin**
P	%	2.30 ±0.05[a]	1.56 ±0.00[b]	0.13 ±0.05[c]	0.17 ±0.00[c]
K	%	3.66 ±0.10[a]	3.55 ±0.00[a]	0.18 ±0.08[c]	0.38 ±0.00[b]
Ca	%	1.94 ±0.32[a]	1.35 ±0.07[b]	0.11 ±0.03[d]	0.17 ±0.00[c]
Mg	%	1.02 ±0.17 [a]	0.79 ±0.03[b]	0.06 ±0.16[d]	0.09 ±0.00[c]
Fe	ppm	165 ±7.33[a]	58.6 ±3.03[b]	16.9 ±1.13[c]	10.6 ±4.41[c]
Mn	ppm	57.3 ±0.90[a]	46.9 ±0.10[b]	3.89 ±0.58[d]	16.8 ±0.19[c]
Cu	ppm	46.7 ±4.42[a]	44.7 ±0.62[a]	5.98 ±1.21[b]	10.7 ±1.07[b]
Zn	ppm	112 ±1.27[a]	84.9 ±0.87[b]	9.49 ±1.53[c]	8.46 ±0.49[c]
Ge	ppm	18.24 ±0.98[a]	13.8 ±0.48[b]	5.11 ±0.16[c]	4.85 ±0.81[c]

Values are mean ±SEM of carefully conducted triplicate experiments as mg/100 g, Furthermore, mean carrying different superscripted alphabets vary significantly (p<0.05) with 95% confidence.

Discussion

The analysis of G. *lucidum* MG2 and G2 powder through sprayed dry found that the nutritional value as a good source of energy carbohydrate, protein and minerals. Carbohydrate content of *G. lucidum* MG2 and G2 maltodextrin added to lingzhi on a spray dring. It is found that carbohydrate content of *G. lucidum* MG2 and G2 maltodextrin added lingzhi on a spray dring as the maltodextrin is polysaccharide type which obtained by digesting starch molecules to be powder form or flake of white color which is not flavored. Maltodextrin is widely used in food products and food industry to prevent clotting (anticaking agent) (Soonthorncharoennon (2000).

G. lucidum MG2 had the highest protein composition. The variance in lingzhi protein content could be attributed to a variety of factors including lingzhi type, stage of growth, component samples, nitrogen availability, substrates, and habitat. (Zahid *et al.*, 2010). Lipid content of lingzhi powder is lowest fat. The amount of fat composition in *G. lucidum* MG2 and G2 of lingzhi found to be low leading to be a good nutritional value due to low amount of fat which can be recommended as healthy products according to experiments. Because lingzhi lipids are primarily unsaturated fatty acids with little fat content, they have no influenced in blood cholesterol levels (Zahid *et al* (2010).

Ash content of *G. lucidum* MG2 and G2 was elucidated. It is the most important substance was found n *Ganoderma lucidum* MG2. It is reported by Muang Ngai Agricultural Park Special Project whioch found that the production of lingzhi was similar trends.–With this, (Zahid et al, 2010) stated cthat the total yield of G. *lucidum* MG2 was appreciated to be the best strain for commercial lingzhi cultivation.

The moisture contents of *G. lucidum* G2 and MG2 powder without added maltodextrin during spray drying process were found to be the highest values. Maltodextrin was contributed a solid component to the mixture with reducing free water activities, and leading to the moisture values dropped and anti-caking chemicals are used (Sornsomboonsuk *et al*., 2018). The differences in calorie content between *G. lucidum* strains MG2 and G2 G were found. During spray drying process, *G. lucidum* with maltodextrin added showed a high calorie content due to the qualities of maltodextrin, a polysaccharide carbohydrate is partially digested from starch molecules into short lines of glucose. operatives (Sornsomboonsuk *et al*., 2018).

In this study, *G. lucidum* strains MG2 and G2 powder producing in commercial processing to be powderv forms would be feasible promoted. It is concluded that the powder peoduct of lingzhi can be offered as a good nutritional value, low fat content, low energy value and as a source of minerals. *G. lucidum* strains *MG2* and *G2* are made in powder forms by commercial processing using spray dry and maltodextrin added in the process can increase to be high calorie and carbohydrates.

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