Current Research in Environmental & Applied Mycology (Journal of Fungal Biology)
11(1): 37–50 (2021) ISSN 2229-2225
www.creamjournal.org

Article

Doi 10.5943/cream/11/1/3

Mycochemical screening, proximate nutritive composition and radical scavenging activity of *Cyclocybe cylindracea* and *Pleurotus cornucopiae*

Landingin HRR[1], Francisco BE[1], Dulay RMR[1,2], Kalaw SP[1,2] and Reyes RG[1,2]

[1]*Center for Tropical Mushroom Research and Development, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines*
[2]*Department of Biological Sciences, College of Arts and Sciences, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines*

Landingin HRR, Francisco BE, Dulay RMR, Kalaw SP, Reyes RG 2021 – Mycochemical screening, proximate nutritive composition and radical scavenging activity of *Cyclocybe cylindracea* and *Pleurotus cornucopiae*. Current Research in Environmental & Applied Mycology (Journal of Fungal Biology) 11(1), 37–50, Doi 10.5943/cream/11/1/3

Abstract

This work evaluated the mycochemical and proximate composition analysis of the fruiting body extracts of *Cyclocybe cylindracea* and *Pleurotus cornucopiae* in order to determine its nutraceutical and pharmacological potential. Extracts of the two exotic mushroom species were obtained using ethanol. The DPPH radical scavenging activity and total phenolic content of the extract were also investigated. Both *C. cylindracea* and *P. cornucopiae* contained essential oil, triterpenes, anthraquinones, tannins, flavonoids, phenols, anthrones, fatty acids, alkaloids, steroids, sugars and coumarins. However, anthraquinones and flavonoids were not found in *P. cornucopiae*. In addition, *C. cylindracea* contains crude protein (13.5%), crude fat (1.52%), ash content (12.15%), moisture (10.68%), carbohydrates (62.15%) with 316.28 kcal energy value, and exhibits radical scavenging activity (40%) and total phenolic (41.08 mg GAE/g). On the other hand, *P. cornucopiae* had crude protein (11.98%), crude fat (1.32%), ash content (6.58%), moisture (9.07%), carbohydrates (71.05%) with 344 kcal energy value, and reveals radical scavenging activity (41.75%) and total phenolic (39.63 mg GAE/g). Therefore, the two exotic species of mushrooms could be considered as healthy food source with pharmacological benefits.

Key words – antioxidant – *Cyclocybe cylindracea* – mycochemical screening – *Pleurotus cornucopiae* – proximate composition analysis – radical scavenging activity – total phenolic content

Introduction

In the past few decades, investigations on the functional and pharmacological potential of wild and edible mushrooms have been dynamically expounded. Mushrooms are considered to be rich in nutrients and other natural mycochemicals that have wide ranges of nutritional and health benefits (Cheung 2010), both preventive and therapeutic effects; as a result, have aroused the attention of many consumers and researchers throughout the world (Carrasco et al. 2018). Mushrooms contain abundance of vitamins (thiamine, riboflavin, ascorbic acid, ergosterol, and niacin) and essential amino acids. They also have proteins, fats, ash, glycosides, volatile oils, tocopherols, phenolic compounds, flavonoids, carotenoids, folates, organic acids, etc. (Puri 2017,

Submitted 27 August 2020, Accepted 3 December 2020, Published 22 January 2021
Corresponding Author: Harold Ray R. Landingin – e-mail – haroldray_99@yahoo.com

Sánchez 2017). Mushrooms also exhibit anti-inflammatory, antioxidant, immunomodulatory, anti-carcinogenic, anti-viral, anti-bacterial, anti-fungal, hepatoprotective, anti-neurodegenerative, anti-diabetic, anti-angiogenic, and hypoglycemic properties, among others (Badalyan 2012, Elsayed et al. 2014, Xu & Beelman 2015).

In the Philippines, several studies have been elucidated to determine the nutritional benefits and functional activities of different species of native and exotic mushrooms. Previous studies showed that *Volvariella volvacea* exhibit anti-coagulation, anti-inflammatory and anti-hypertension activities (Eguchi et al. 2015) while *Lentinus tigrinus* and *Pleurotus djamor* showed antioxidant properties (Dulay et al. 2016b). Also, there is high amount of protein, crude fiber, ash and carbohydrates found in *P. cystidiosus*, *P. florida* and *P. ostreatus* (Amabye & Bezabh 2015, Bernas et al. 2006, Kalaw & Albinto 2014), while abundant source of mycochemicals in *L. sajor-caju* (De Leon et al. 2017). Moreover, these mushrooms are cultivated on the tropical condition of the country for the development of its production technology. In fact, the Center for Tropical Mushroom Research and Development continues to acquire new exotic species of mushrooms to examine its potential as source of food and nutrients. *Cyclocybe cylindracea,* an edible white rot basidiomycete, is successfully cultivated under the tropical condition of the Philippines (Landingin et al. 2020). Possessing abundant amount of proteins and carbohydrates, it is known for biosynthesis of several secondary metabolites that have been studied regarding antioxidative and anti-fungal activity as well as anti-tumor properties (Ngai et al. 2005, Tsai et al. 2006, Zhao et al. 2003). On the other hand, *Pleurotus cornucopiae* var. *citrinopileatus* comprises different micronutrients and antioxidants components (Musieba et al. 2013). Also, it has an excellent anti-diabetic activity and thus has great potential as an ingredient in natural health products (Rushita et al. 2013). These species are potential sources of diverse biomolecules with nutritional and/or medicinal properties, and could be used for the development of medicines, nutraceuticals and food supplements.

Following this approach, this present work intends to evaluate the mycochemical and proximate composition analysis of the fruiting body extracts of *C. cylindracea* and *P. cornucopiae*. Extracts of the two exotic mushroom species were obtained using ethanol solvent. The assessment of nutrient composition focused on the determination of crude protein, crude fat, ash content, moisture content (MC) and total carbohydrates. In addition, DPPH radical scavenging activity and total phenolic contents were also investigated. Results of this study is necessary to stress the fact that the bioactive compounds and nutrients from this two exotic species of mushrooms may play an important role to take advantage on promoting health potential and functions.

Materials & Methods

Source of Mushrooms

The pure culture of *C. cylindracea* and *P. cornucopiae* were obtained from the Center for Tropical Mushroom Research and Development, Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippines. The mushroom mycelia were grown on 750g substrate of rice straw-sawdust (7:3 v/v) based formulation with 60-70% moisture content under tropical condition for one month. After incubation, fruiting bags were opened and transferred in a growing house to allow the emergence of mushroom fruiting bodies. The fruiting bodies were harvested, cut into small pieces and air dried.

Ethanolic Extraction of Mushroom

Ten grams of air-dried fruiting bodies of each mushroom was extracted in 500 ml of 95% ethanol for 48 hours soaking. Extracts were filtered using Whatman filter No.2 and concentrated to dryness using rotary evaporator. The weight of the extract was determined.

Mycochemical Screening of *C. cylindracea* and *P. cornucopiae*

The ethanol extracts of *C. cylindracea* and *P. cornucopiae* were screened to determine the presence of different compounds using reagents such as HCl, NH_3, NaOH, chloroform, Maeyer's reagent following the protocol of Guevarra (2005). Tests were done in triplicates. Results were interpreted as: (+) if chemicals are present in trace amount and (-) if chemicals are absent.

Proximate Composition Analysis

The proximate nutritive composition of the fruiting body extracts of *C. cylindracea* and *P. cornucopiae* were determined. The crude protein, crude fat, ash and moisture content (MC) were analysed following the guidelines of the Association of Official Analytical Chemist International (AOACI 2005). Protein content was determined using distilled H_2O, sulphuric acid, catalyst tablet, H_3BO_3, NaOH and HCl using Kjeldahl method (conversion factor N × 4.38) whereas; crude fat content was determined using Soxhlet apparatus, petroleum ether as reagent. The ash content was determined using furnace at 550°C. Total carbohydrate content was calculated as follows: total carbohydrates = 100 - (protein + fat + ash + MC). Energy value was calculated as Energy (kcal/100 g) = 4 x (protein + carbohydrates) + 9 x (fat) (Ulziijargal & Mau 2011).

Radical Scavenging Activity Assay

The concentrated extract was used to make a stock solution and aliquot was taken to make 1000 ppm dilution and 1000 ppm cathechin as control (1 mg/ml). One ml of the prepared stock solution was mixed with 4 ml of 0.1 mM DPPH solution in separate plastic cuvette following the standard method of Shimada et al. (1992) with modifications. Tests were done in triplicate. The prepared mixtures were incubated in the dark at 37°C for 30 min. The absorbance readings were monitored at 517 nm using a UV VIS spectrophotometer. The ability to scavenge the DPPH radical was calculated using the formula: % Radical Scavenging Effect = $[(A_{control} - A_{sample}) / A_{control}] \times 100$.

Estimation of Total Phenolic Content

The amount of total phenolics in the extracts was determined using Folin-Ciocalteu reagent (Sunita & Dhanajay 2010). Gallic acid was used as a standard and the total phenolic content was calculated as mg/g Gallic Acid Equivalents (GAE). The different concentrations of gallic acid and 1 mg/ml concentration of mushroom extract was prepared in methanol. Each sample (0.5 ml) was introduced into test tubes and mixed with 2.5 ml of a 10 fold dilute Folin-Ciocalteu reagent and 2 ml of 7.5% sodium carbonate. The tubes were covered with parafilm and allowed to stand for 30 min at room temperature prior to absorbance reading at 760 nm spectrophotometrically. All tests were done in triplicate.

Results

Mycochemical Properties

In this study, mycochemical composition of the ethanol extracts of fruiting bodies of *C. cylindracea* and *P. cornucopiae* were screened (Table 1). Both *C. cylindracea* and *P. cornucopiae* contained essential oil, triterpenes, anthraquinones, tannins, flavonoids, phenols, anthrones, fatty acids, alkaloids, steroids, sugars and coumarins. However, anthraquinones and flavonoids were not found in *P. cornucopiae*. These indicate that the two exotic species of mushrooms are rich in mycochemicals that might exhibit pharmacological and nutraceutical properties.

Proximate Nutritional Composition

In this study, proximate nutritional composition of the air-dried fruiting body extracts of *C. cylindracea* and *P. cornucopiae* was analysed (Table 2). The crude protein, crude fat, ash content, moisture content, total carbohydrates and energy value were determined. *C. cylindracea* and *P. cornucopiae* contained all the nutritional components. The two exotic species of mushrooms were found to be rich in protein, ash and moisture content, with very less amount of fat and large amount of carbohydrates. Results revealed that *C. cylindracea* contains higher amounts of crude protein, crude fat, ash content and moisture content than *P. cornucopiae*. In contrast, *P. cornucopiae* exhibited higher calculated amount of carbohydrates and energy value than *C. cylindracea*.

Table 1 Mycochemical compositions of ethanol extracts of fruiting bodies of *C. cylindracea* and *P. cornucopiae*

Mycochemicals	***C. cylindracea***	***P. cornucopiae***
Essential oil	+	+
Triterpenes	+	+
Anthraquinones	+	-
Tannins	+	+
Flavonoids	+	-
Phenols	+	+
Anthrones	+	+
Fatty acid	+	+
Alkaloids	+	+
Steroids	+	+
Sugars	+	+
Coumarins	+	+

(+) positive, (-) not detected

Table 2 Proximate composition of air-dried fruiting bodies of *C. cylindracea* and *P. cornucopiae*

Nutrients	***C. cylindracea***	***P. cornucopiae***
Crude Protein (%)	13.5	11.98
Crude Fat (%)	1.52	1.32
Ash Content (%)	12.15	6.58
Moisture Content (%)	10.68	9.07
Total Carbohydrates (%)	62.15	71.05
Energy value (kcal)	316.28	344

Total carbohydrates and energy were calculated according to the following equation: Total carbohydrates (%) = 100 – (protein + fat + moisture content + ash content); Total energy (kcal) = 4 x (protein + carbohydrates) + 9 x (fat)

Antioxidant Property

The antioxidant activity of *C. cylindracea* and *P. cornucopiae* was evaluated using DPPH radical scavenging activity. As shown in Table 3, *C. cylindracea* exhibited radical scavenging activity of 40.00%, whereas *P. cornucopiae* recorded higher radical scavenging activity of 41.75%. On the other hand, the total phenolic content of the ethanolic extracts in the two exotic species of mushrooms was determined using Folin-Ciocalteu method and the results are also presented in Table 3. Results showed significant amount of total phenolics in *C. cylindracea* and *P.cornucopiae* having 41.08 mg GAE/g and 39.63 mg GAE/g, respectively.

Table 3 Radical Scavenging Activity and Total Phenolic Content of *C. cylindracea* and *P. cornucopiae*

Extract	**Radical scavenging activity (%)**	**Total phenolics (mg GAE/g of sample)**
C. cylindracea	40.00	41.08
P. cornucopiae	41.75	39.63
Catechin (control)	65.22	

Discussion

Mycochemicals are naturally occurring chemicals produced by fungi which perform metabolic functions. They exhibit significant human health benefits (De Leon et al. 2017). Essential oil has aromatherapeutic property and anti-microbial activities (Yayli et al. 2007). They are widely used in the cosmetics industry and perfumery (Dhifi et al. 2016). Triterpenes which have cancer preventive or anti-tumour efficacy towards various tumour cells may play a role in breast cancer prevention (Xue et al. 2015). It also possesses a chemical defense against environmental stress and provides a repair mechanism for wounds and injuries (Battineni et al. 2018). Anthraquinones exhibit antibacterial, antiparasitic, insecticidal, fungicidal, and antiviral properties. They are also used as anticancer agents (Gessler et al. 2013). In addition, these compounds are used in analytical chemistry and industrial processes for the production of cellulose. It can be applied as dyes, agrochemicals, and prototypes for the development of new molecules with biological activities (Diaz et al. 2018). Tannins play a vital role as a raw material for sustainable green industries such as leather, feeds, and beverages among others. Interestingly, tannins were also used as potential medicinal agents, antioxidants, metal chelators; and act as inhibitors of harmful preoxidative enzymes and of lipid peroxidation process. Several substantial activities such as antiseptics, anticarcinogenic, and anti-inflammatory of tannins have been documented in humans that can provide potential assistances on pharmaceutical and nutraceutical industries (Singh & Kumar 2019). Flavonoids are now considered as an essential factor in a variety of nutraceutical, pharmaceutical, medicinal and cosmetic applications. This is ascribed to their anti-oxidative, anti-inflammatory, anti-mutagenic and anti-carcinogenic activities coupled with their capacity to control key cellular enzyme functions (Panche et al. 2016). Phenolic acids were the major phenolic compounds reported in mushrooms to be rich source of antioxidants with immense antiradical activity (Valentão et al. 2005). In addition, phenols are important mushroom constituents because of their scavenging ability due to their hydroxyl groups (Alispahić et al. 2015). Anthrones are used for a common cellulose assay and in the colorometric determination of carbohydrates, and can be used in pharmacy as laxative (Treveylan et al. 1952). Fatty acids play a major role in the functioning of the immune system and the maintenance of all hormonal systems in the body (Hanus et al. 2008). Alkaloids possess therapeutic capabilities and physiological effect that renders valuable medicine against various diseases including cancer, diabetes, asthma, malaria, cardiac dysfunction etc. (Kittakoop et al. 2014, Mahajan et al. 2011). Steroids contain anti-inflammatory properties which manages tissue damages (Lindequist et al. 2005). The coumarins are of great importance due to their pharmacological applications. In particular, their physiological, bacteriostatic and anti-tumor property makes these compounds as elite therapeutic agents (Jain & Joshi 2012).

Studies related on the nutritional value of wild and cultivated mushrooms were also reported on previous researches. Rathee et al. (2012) and Xu et al. (2010) reported that *Ganoderma lucidum* contains triterpenes which have anti-inflammatory activity and ganoderic acids which have anti-tumor activity. In addition, *Agrocybe cylindracea* contains β-glucans which have anti-oxidant activity and are able to enhance the immune system. It also has agrocybin (peptide) which has hypoglycemic and anti-fungal property (Batbayar et al. 2012, Gupta et al. 2014, Ngai et al. 2005, Rathee et al. 2012, Zhang et al. 2003). Palacios et al. (2011) also indicated that *Canthrarellus cibarius* contains flavonoids which have anti-microbial property. Phan et al. (2019) reported that the aqueous extract of *Pleurotus giganteus* exhibits bioactive secondary metabolites such as sterols and triterpenes. Dasgupta et al. (2015) and Sowndhararajan et al. (2013) also stated that *Gomphus floccosus* contains phenols, flavonoids and β-carotene and low amounts of lycopene which are known to possess strong antioxidative characteristics. Guillamón et al. (2010) conveyed that the amount and efficiency of the bioactive compounds depend on the mushroom species, substrate, fruiting conditions, stage of development, age, storage conditions, and pasteurization process. Generally, the abundant amount of mycochemicals detected on the two ethanol extracts of *C. cylindracea* and *P. cornucopiae* might draw attention to its effectiveness in antioxidant activities that possess curative, protective and defensive potential. Essential mycochemicals contained in fungi have attained more attention due to their characteristics to constrain several diseases (Devi et al. 2012).

Mushrooms are considered to be good source of many nutrients with various human helath benefits. Edible mushrooms contain many different bioactive compounds such as high protein, fiber, vitamin and mineral contents, and low-fat levels (Flegg & Maw 1997, Gruen & Wong 1982). The chemical composition of mushrooms is affected by different factors such as mushroom species and growth media composition. It can also be altered by the time of harvest, management techniques, handling conditions and substrate formulation (Amabye & Bezabh 2015). Protein is the most critical component contributing nutritional value of food. Mushroom proteins constitute more than half of total nitrogen and are known to contain almost all the essential amino acids. The presence of proteins is an indication that they are highly nutritious and good for human consumption (Adedayo 2011, Giri et al. 2013, Raneses et al. 2016). The crude protein obtained in *C. cylindracea* in this present work is closer to the values obtained in *Volvariella volvacea* (13.38%) (Yuen et al. 2014). This value is slightly lower than *Lentinus tigrinus* (18.07%) (Manjunathan et al. 2011) and *Ganoderma lucidum* (16.07%) (Salamat et al. 2017). However, this value is higher than *Auricularia auricular-judae* (8.36%) obtained by Afiukwa et al. (2015). On the other hand, the crude protein obtained in *P. cornucopiae* is relatively higher than the values revealed by Zahid et al. (2012) in *Pleurotus ostreatus* (4.83%), *Pleurotus sajor-caju* (4.2%) and *Pleurotus florida* (3.29%) but is lower than the values obtained by Eze et al. (2014) in *Pleurotus tuber-regium* (17.47%) and Salamat et al. (2017) in *Pleurotus eryngii* (18.9%). The protein content could be attributed to the number of factors such as composition of the substratum, species of mushrooms, its developmental stage, its sampled part and the availability of N2 to the growing mushrooms (Barros et al. 2007). In fact, these edible mushrooms are relatively higher as compared to other food crops such as maize (9.87%), rice (7-8%), wheat (10.6%) and potato (2%) (Chaudhari et al. 2018, Sule Enyisi et al. 2014). In addition, Bano (1993) reported that the protein value of mushrooms is almost twice that of potatoes, four times that of tomatoes and carrots and six times that of oranges (Jiskani 2001). Therefore, *C. cylindracea* and *P. cornucopiae* contains proteins which can be an excellent substitute to other food crops; thus, enhancing food nutrition and supplementation.

Crude fat has been variable in mushrooms and factors that might influence fat content have not yet been completely elucidated (Kurtzman 1997). Mushrooms are regarded as low calorie foods. This low calorie value is attributed to the content of high fiber, low fat , no cholesterol and no free fatty acids in mushrooms. Mushrooms have no cholesterol and are virtually low in fat. The fat content of an edible mushroom contains mostly unsaturated fatty acids which are less hazardous to the health than the saturated fatty acids (Breene 1990). *C. cylindracea* had 1.52% crude fat content and *P. cornucopiae* had 1.32% which is much lower than *Termitomyces robustus* (5.81%) (Adebiyi et al. 2016) and higher than *Cyclocybe aegerita* (0.2%) (Muthu & Shanmugasundaram 2016). This fat content of *C. cylindracea* and *P. cornucopiae* is close to the fat content of *Leucopaxillus candidus* (1.8%) and *Pleurotus florida* (1.54%) (Teklit 2015, Vieira et al. 2016). Although mushrooms are low in fat, they do contain essential unsaturated fatty acids, considered essential and significant for human diet and health (Mshandete & Cuff 2007).

The mushrooms evaluated have reasonable amounts of ash content, an indication of rich mineral constituent (Afiukwa et al. 2015). The result of the present work showed that *C. cylindracea* contains 12.15% ash content which is higher than *Pleurotus florida* (9.41%), *Calocybe indica* (6.5%) and *Lentinus sajor-caju* (4.89%) but lower than *Russula delica* (17.92%) ash content (Gaur et al. 2016, Raneses et al. 2016, Teklit 2015). Conversely, *P. cornucopiae* recorded 6.58% ash content which is much higher than *Cantharellus cibarius* (1.77%), *Lactarius piperatus* (0.81%), and *Boletus edulis* (1.15%) and lower than *Agaricus bisporus* (7.01%) ash content (Çaglarlrmak et al. 2001, Teklit 2015). Variation in the amount of ash content might be influenced by the chemical composition of mushrooms (Silva et al. 2002). The results from the ash content determination obtained from *C. cylindracea* and *P. cornucopiae* indicates that it is a good source of minerals that play an essential role in terms of physiochemical and nutritional point of view.

Moisture content of some of the mushrooms analyzed is high, indicating that mushrooms are highly perishable. High moisture content promotes susceptibility to microbial growth and enzyme activity (Adejumo & Awosanya 2005). The moisture content is also an important indication of the shelf life of the sample (Adebiyi et al. 2016). Suitable handling processes normally involve heat transfer such as cooling, freezing, sterilizing, and drying of the fruiting bodies (Saenmuang et al. 2017). The result of the study showed that *C. cylindracea* contains 10.68% while *P. cornucopiae* contains 9.07% moisture content which is lower than *L. sajor-caju* (12.21%) (Raneses et al. 2016) and *Pleurotus eryngii* (15.59%) (Enas et al. 2016). Generally, the moisture content of mushroom is greatly affected by different factors such as harvesting time, maturation period and environmental conditions such as humidity, temperature, growing period, storage condition etc. (Kalac 2009).

Carbohydrates are considered as the vital form of biological macromolecules that are important in the human nutrition and energy source to the body (Colak et al. 2009). A considerable proportion of the carbohydrates occur in the form of polysaccharides with particles of different size represented by glycogen, dietary fiber, cellulose, chitin, mannans and glucans (Bernas et al. 2006). The carbohydrate content of mushrooms represents the bulk of fruiting bodies accounting for 50 to 65% on dry weight basis (Wani et al. 2010). In this study, *C. cylindracea* had 62.15% total carbohydrates. This value is higher than the values obtained by Saenmuang et al. (2017) in *Amanita hemibapha* and *Termitomyces globules* having 50.5-51.8% total carbohydrates but lower than *Agaricus bisporus* (74%) and *Lentinus edodes* (87.1%) of total carbohydrates (Valverde et al. 2015). On the other hand, *P.cornucopiae* had 71.05% of total carbohydrates which is much higher than the values obtained by Alam et al. (2008) in *Pleurotus ostreatus* (37.8%), *Pleurotus sajor-caju* (39.82%) and *Pleurotus florida* (42.83%) but lower than the values reported by Valverde et al. (2015) in *Pleurotus giganteus* (78%) and *Pleurotus eryngii* (81.4%). The findings of the present study showed that *C. cylindracea* and *P. cornucopiae* can be a good source of carbohydrates which can be substituted to other food crops as energy source. In addition, mushroom polysaccharides have antitumor action that could prevent stress on the body and they may produce around 50% reduction in tumor size (Wasser 2002, Zhang et al 2007).

The main sources of dietary energy are fats and carbohydrates, thus proteins are capable of providing dietary energy. The energy value obtained from edible mushrooms is quite higher than other food sources such as meat, chicken, fish and vegetables (O'Neil et al. 2012). The energy value of *C. cylindracea* and *P.cornucopiae* was calculated as 316.28 and 344 kcal, respectively. These values are higher than the values obtained by Nakalembe et al. (2015) in *Volvariella speciosa* (220.62 kcal) and Kakon et al. (2012) in *Volvariella diplosia* (304 kcal). However, these are lower than the values recorded in *Lentinus squarrosulus* (325.4 kcal), *Calocybe gambosa* (355.33 kcal) and *Podaxis pistillaris* (387.05 kcal). The outcomes of the present study indicate that *C. cylindracea* and *P. cornucopiae* can be an ideal source of nutrition and source of energy which can be an alternative rich food source. For instance, energy value of mushrooms is higher than chicken eggs (143 kcal/100 g serving), yogurt (59kcal/100 g serving), vegetable products (23 kcal-106 kcal/100 g serving), and certain types of beans (pinto beans, lima beans, and kidney beans; 29 kcal-113 kcal/100 g serving). However, nuts (553 kcal-579 kcal/100 g serving) and lamb loin (310 kcal/100 g serving) contains much more energy content. Mushroom's nutritional value proves to have many health and nutritional benefits. Furthermore, the recommended level of energy requirements often fluctuates depending on an individual's body size, lifestyle, and level of activity (Westerterp 2014).

Antioxidants play a vital role as protection against oxidative damages caused by free radicals that causes anemia, asthma, premature sign of aging and cancer (Buricova & Reblova 2007, Jose & Janardhanan 2000). According to Chennupati et al. (2012), these antioxidants address several diseases by protecting the cells from oxidative stress; scavenging free radicals, chelating catalytic metals and halting lipid peroxidation chain reactions. The DPPH assay is a simple, acceptable and most widely used technique to evaluate the radical scavenging potency of any potential substances or compounds (Dudonné et al. 2009). Antioxidants are capable of enacting the visually noticeable quenching of the stable purple-coloured DPPH radical to the yellow-coloured DPPH (Chang et al. 2002). The values obtained are relatively lower to the percentage radical scavenging activity obtained by Alispahić et al. (2015) in *Pleurotus ostreatus* (43.88%). The values are much higher than *Agaricus bisporus* (1.67%) and *Agaricus brasiliensis* (2.77%) of Gan et al. (2013). However, the values are lower than the amount of *Trametes elegans* (57.56%) obtained by Nanglihan et al. (2018). In addition, the percentage radical scavenging activity of the two exotic species of mushrooms in this present work is much higher than the total amount obtained by Tsai et al. (2006) in the fruiting bodies of *C. cylindracea* (30.46%) and Yildiz et al. (2017) in the fruiting bodies of *Pleurotus citrinopileatus* (6.48%) grown on sawdust. This clearly indicates that *C. cylindracea* and *P. cornucopiae* have promising potential in the pharmaceutical industry because antioxidants perform significant physiological functions in preventing diseases related with free radicals. The antioxidant activity of mushroom may also vary in their fruiting body, mycelia and spent media (Dulay et al. 2016a). Also, the radical scavenging activity of the mushroom species is attributed to the presence of mycochemicals, specifically the phenolic compounds such as alkaloids, flavonoids, and glycosides (Herraiz & Galisteo 2002, Pietta 2000, Zhang et al. 2006).

Phenolics are considered antioxidants because of their ability to chelate metals, inhibit lypoxygenase and scavenge free radicals due to their hydroxyl groups (Hatano et al. 1989, Martinez-Valverde et al. 2000). Phenolics are present in different foods particularly in mushrooms (Dulay et al. 2016a). They are known to prevent heart ailments, fight cancer and considered as anti-inflammatory agents (Doughari 2012). To consider the importance of polyphenolic compounds and its presence in many species of mushrooms, the total antioxidant activity of *C. cylindracea* and *P. cornucopiae* was determined. The results are close to the phenolic content obtained by Aquino et al. (2018) in the ethanolic extract of *Polyporus grammocephalus* (38.58 mg GAE/g of sample). On the other hand, the values obtained in the present study are much higher to the phenolic content investigated by Wong et al. (2013) in *Pleurotus eryngii* (3.57 mg GAE/g of sample), *Pleurotus florida* (3.72 mg GAE/ g of sample) and *Auricularia polytricha* (6.03 mg GAE/ g of sample) but much lower to the phenolic content obtained by Bustillos et al. (2018) in the mycelial mat extract of *Pleurotus djamor* (258.91 mg AAE/g sample) and *Ganoderma lucidum* (398.52 mg AAE/g sample) grown in coconut water broth. The results of this study strongly indicate that *C. cylindracea* and *P. cornucopiae* extracts possess active phenolics as good source of antioxidant activity. In addition, their rich antioxidant contents make the mushroom ideal nutritional supplement. Phenolic compounds have been reported to possess anticancer or anti carcinogenic/anti-mutagenic, anti-atherosclerotic, anti-bacterial, anti-viral, and anti-inflammatory activities (Attarat & Phermthai 2014, Nagai et al. 2003). The composition of phenolic contents of mushrooms generally depends on genetic, environmental and other factors (Heleno et al. 2010).

Acknowledgements

This research was funded by the Academic Research Council (ARC), Central Luzon State University, Central Luzon, Philippines. Our warmest gratitude was given to the Science Education Institute of the Department of Science and Technology, Taguig City, Philippines.

References

Adebiyi AO, Tedela PO, Atolagbe TT. 2016 – Proximate and mineral composition of an edible mushroom, *Termitomyces robustus* (Beeli) Heim in Kwara State, Nigeria. American Journal of Food and Nutrition 6(3), 65–68.

Adedayo MR. 2011 – Proximate analysis on four edible mushrooms. Nigerian Stored Product Research Institute 15 (1), 9–11.

Adejumo TO, Awosanya OB. 2005 – Proximate and mineral composition of four edible mushroom species from South Western Nigeria. African Journal of Biotechnology 4 (10), 1084–1088.

Afiukwa CA, Ebem EC, Igwe OD. 2015 – Characterization of the proximate and amino acid composition of edible wild mushroom species in Abakaliki, Nigeria. American Association of Science and Technology Journal of Bioscience 1(2), 20–25.

Aquino YKDC, Vega LDP, Medrano NRM, Dulay RMR. 2018 – Mycochemicals, antioxidant and cytotoxic activities of *Polyporus grammocephalus* Berk (BIL7749). International Journal of Biology, Pharmacy and Allied Sciences 7(6), 966–975.

Alam N, Amin R, Khan I, Shim MJ et al. 2008 – Nutritional analysis of cultivated mushrooms in Bangladesh – *Pleurotus ostreatus*, *Pleurotus sajor-caju*, *Pleurotus florida* and *Calocybe indica*. Mycobiology 36(4), 228–232.

Alispahić A, Šapčanin A, Salihović M, Ramić E et al. 2015 – Phenolic content and antioxidant activity of mushroom extracts from Bosnian market. Bulletin of the Chemists and Technologists of Bosnia and Herzegovina 44, 5–8.

Amabye TG, Bezabh AM. 2015 – Chemical composition and nutritional value of the most widely used mushrooms cultivated in Mekelle Tigray, Ethiopia. American Journal of Applied Chemistry 3(5), 164–167. Doi 10.11648/j.ajac.20150305.12.

AOACI. 2005 – Official Methods of Analysis (18th edition) Association of Official Analytical, Chemists International, Maryland, USA.

Attarat J, Phermthai T. 2014 – Bioactive compounds in three edible *Lentinus* mushrooms. Walailak Journal of Science and Technology 12, 491–504.

Badalyan S. 2012 – Medicinal aspects of edible ectomycorrhizal mushrooms. DDM 34. Springer, Berlin, 317–334.

Bano Z. 1993 – Food value of mushrooms. Gram Prandyogiki 3, 224–225.

Barros L, Baptista P, Correia DM, Casal S et al. 2007 – Fatty acid and sugar compositions, and nutritional value of five wild edible mushrooms from Northeast Portugal, Food Chemistry 105, 140–145.

Batbayar S, Lee DH, Kim HW. 2012 – Immunomodulation of fungal b-glucan in host defense signaling by dectin-1. Biomolecules and Therapeutics 20(5), 433–445. Doi 10.4062/biomolther20.5.433.

Battineni JK, Koneti PK, Bakshi V, Boggula N. 2018 – Triterpenoids: a review. International Journal of Research in Pharmacy and Pharmaceutical Sciences 3(2), 91–96.

Bernas E, Jaworska G, Lisiewska Z. 2006 – Edible mushrooms as a source of valuable nutritive constituents. Acta Scientiarum Polonorum, Technologia Alimentaria 5(1): 5–20.

Breene W. 1990 – Nutritional and medicinal value of mushrooms. Journal of Food Production 53, 883–894.

Buricova L, Reblova Z. 2007 – Medicinal plants as possible sources of antioxidants. Czech Journal of Food Science 26(2), 132–138.

Bustillos RG, Francisco CS, Dulay RMR. 2018 – Liquid culture and antioxidant properties of *Ganoderma lucidum* and *Pleurotus djamor*. International Journal of Biology, Pharmacy and Allied Sciences 7(4), 576–583.

Çaglarlrmak N, Ünal K, Ötles S. 2001 – Nutritional value of edible wild mushrooms collected from the black sea region of Turkey. Micologia Aplicada International 14(1), 1–5.

Carrasco J, Zied DC, Pardo JE, Preston GM, Pardo-Gimenez A. 2018 – Supplementation in mushroom crops and its impact on yield and quality. Springer 8, 146.

Chang LW, Yen WJ, Huang SC, Duh PD. 2002 – Antioxidant activity of sesame coat. Food Chemistry 78, 347–354.

Chaudhari PR, Tamrakar N, Singh L, Tandon A, Sharma D. 2018 – Rice nutritional and medicinal properties: A review article. Journal of Pharmacognosy and Phytochemistry 7(2), 150–156.

Chennupati S, Valluru S, Bhogavalli P. 2012 – Studies on antioxidant capacity of petroleum ether and acetone extracts of *Pleurotus florida*. Asian Journal of Biochemical and Pharmaceutical Research 2(2), 82–88.

Cheung PCK. 2010 – The nutritional and health benefits of mushrooms. Nutrition Bulletin 35, 292–299.

Colak A, Kolcuoğlu Y, Sesli E, Dalman O. 2009 – Biochemical composition of some Turkish fungi. Asian Journal of Chemistry 19, 2193–2199.

Dasgupta A, Paloi S, Acharya K. 2015 – Mycochemical analysis and antioxidant efficacy of a wild edible mushroom from the Eastern Himalayas. Research Journal of Pharmaceutical, Biological and Chemical Sciences 6(4), 943.

De Leon AM, Orpilla JOV, Cruz KV, Dulay RMR et al. 2017 – Optimization of mycelial growth and mycochemical screening of *Lentinus sajor-caju* (fr.) from Banaue, Ifugao Province, Philippines. International Journal of Agricultural Technology 13(7.3), 2549–2567.

Devi P, Rodrigues C, Naik CG, D'Souza L. 2012 – Isolation and characterization of antibacterial compound from a Mangrove-endophytic Fungus, *Penicillum chrysogenum* MTCC 5108. Indian Journal of Microbiology 52 (4), 617–623.

Dhifi W, Bellili S, Jazi S, Bahloul N, Mnif W. 2016 – Essential oils' chemical characterization and investigation of some biological activities: a critical review. Medicines, 3, 25.

Diaz G, Miranda I, Sartori SK, de Rezende DC. 2018 – Anthraquinones: an overview. Studies in Natural Products Chemistry, 313–338.

Doughari J. 2012 – Phytochemicals: extraction methods, basic structures and mode of action as potential chemotherapeutic agents. Phytochemicals- a global perspective of their role in nutrition and health, 1–33.

Dudonné S, Vitrac X, Coutiere P, Woillez M, Mérillon JM. 2009 – Comparative study of antioxidant properties and total phenolic content of 30 plant extracts of industrial interest using DPPH, ABTS, FRAP, SOD, and ORAC assays. Journal of Agricultural and Food Chemistry 57, 1768–1774.

Dulay RMR, Vicente JJA, Dela Cruz AG, Gagarin JM et al. 2016a – Antioxidant activity and total phenolic content of *Volvariella volvacea* and *Schizophyllum commune* mycelia cultured in indigenous liquid media. Mycosphere 7 (2), 131–138.

Dulay RMR, Miranda LA, Malasaga JS, Kalaw SP et al. 2016b – Antioxidant and antibacterial activities of acetonitrile and hexane extracts of *Lentinus tigrinus* and *Pleurotus djamour*. Biocatalysis and Agricultural Biotechnology.

Eguchi F, Kalaw SP, Dulay RMR, Miyasawa N et al. 2015 – Nutrient composition and functional activity of different stages in the fruiting body development of Philippine paddy straw mushroom, *Volvariella volvacea* (Bull.:Fr.) Sing. Advances in Environmental Biology 9(22), 54–65.

Elsayed EA, Enshasy HE, Wadaan MAM. 2014 – Mushrooms: a potential natural source of anti-inflammatory compounds for medical applications. Mediators of Inflammation 1, 1–15. Doi 10.1155/2014/80584

Enas AE, Sabahelkhier MK, Malaz MM. 2016 – Nutritional composition and minerals content of five species of wild edible mushroom, brought from UAE: mushroom considered as protein source. International Journal of Advanced Research 4(2), 1108–1112.

Eze CS, Amadi JE, Emeka AN. 2014 – Survey and proximate analysis of edible mushrooms in Enugu State, Nigeria. Annals of Experimental Biology 2(3), 52–57.

Flegg PB, Maw G. 1997 – "Mushrooms and their possible contribution to the world," Mushroom Journal 48, 395–403.

Gan CH, Nurul Amira B, Asmah R. 2013 – Antioxidant analysis of different types of edible mushrooms (*Agaricus bisporous* and *Agaricus brasiliensis*). International Food Research Journal 20(3), 1095–1102.

Gaur T, Rao PB, Kushwaha KPS. 2016 – Nutritional and anti-nutritional components of some selected edible mushroom species. Indian Journal of Natural Products and Resources 7(2), 155–161.

Gessler NN, Egorova AS, Belozerskaya TA. 2013 – Fungal anthraquinones. Applied Biochemistry and Microbiology 49(2), 85–99.

Giri S, Mandal S, Acharya K. 2013 – Proximate analysis of three wild edible mushrooms of West Bengal, India. International Journal of Phram Tech Research 5, 365–369.

Gruen FH, Wong MW. 1982 – "Distribution of cellular amino acids, proteins and total nitrogen during fruit body development in Flammuling velutipes," Canadian Journal of Botany 160, 1339–1341.
Guevarra BQ. 2005 – Phytochemical, microbiological and pharmacological screening of medicinal plants. University of Sto. Tomas, Manila, Philippines. bioflux.com. 3, 112–123.
Guillamón S, García-Lafuente A, Lozano M. 2010 – Edible mushrooms: role in the prevention of cardiovascular diseases. Fitoterapia 81(7), 715–723. Doi 10.1016/j.fitote.2010.06.005
Gupta VK, Tuohy MG, O'Donovan A. 2014 – Biotechnology of bioactive compounds: sources and applications. Blackwell, London.
Hanus LO, Shkrob I, Dembitsky VM. 2008 – Lipids and fatty acids of wild edible mushrooms of the genus *Boletus*. Journal of Food Lipids 15(3), 370–383.
Hatano T, Edamatsu R, Mori A, Fujita Y, Yasuhara E. 1989 – Effect of interaction of tannins with coexisting substances. VI. Effects of tannins and related polyphenols on superoxide anion radical and on DPPH radical. Chemical and Pharmaceutical Bulletin (Tokyo) 37, 2016–2021.
Heleno SA, Barros L, Sousa MJ, Martins A, Ferreira IC. 2010 – Tocopherols composition of Portuguese wild mushrooms with antioxidant capacity. Food Chemistry 119, 1443–1450.
Herraiz T, Galisteo J. 2002 – Tetrahydro-βcarboline alkaloids that occur in foods and biological systems act as radical scavengers and antioxidants in the ABTS assay. Free Radical Research 36(8), 923–928.
Jain PK, Joshi H. 2012 – Coumarin: chemical and pharmacological profile. Journal of Applied Pharmaceutical Science 02(6), 236–240.
Jiskani MM. 2001 – Energy potential of mushrooms. The DAWN economic and business review, 4.
Jose N, Janardhanan K. 2000 – Antioxidant and antitumour activity of *Pleurotus florida*. Current Science 79(7), 941–943.
Kakon AJ, Choudhury BK, Saha S. 2012 – Mushroom is an ideal food supplement. Journal of Dhaka National Medical College Hospital 18(1), 58–62.
Kalac P. 2009 – Chemical composition and nutritional value of European species of wild growing mushrooms: A review. Food Chemistry 113, 9–16.
Kalaw SP, Albinto RF. 2014 – Functional activities of Philippine wild strain of *Coprinus comatus* (O. F. Müll.: Fr.) Pers and *Pleurotus cystidiosus* (O. K. Miller) grown on rice straw based substrate formulation. Mycosphere 5(5), 646–655.
Kittakoop P, Mahidol C, Ruchirawat S. 2014 – Current Topics in Medicinal Chemistry. 14(2), 239–252.
Kurtzman RH. 1997 – Nutrition from mushrooms, understanding and reconciling available data. Mycoscience. 38, 247–253.
Landingin HRR, Francisco BE, Dulay RMR, Kalaw SP, Reyes RG. 2020 – Optimization of culture conditions for mycelial growth and basidiocarp production of *Cyclocybe cylindracea* (Maire). The CLSU International Journal of Science and Technology 4(1), 1–17.
Lindequist T, Niedermeyer HJ, Jülich WD. 2005 – The Pharmacological potential of mushrooms. Evid Based Complement Alternat Med 2(3), 285–299.
Mahajan M, Kumar V, Yadav SK. 2011 – Alkaloids: properties, application and pharmacological effects, 1–15.
Manjunathan J, Subbulakshmi N, Shanmugapriya R, Kaviyarasan V. 2011 – Proximate and mineral composition of four edible mushroom species from South India. International Journal of Biodiversity and Conservation 3(8), 386–388.
Martinez-Valverde I, Periag MJ, Ros G. 2000 – Archivos Latinoamericanos de Nutricion 50(1), 5–18.
Mshandete AM, Cuff J. 2007 – Proximate and nutrient compositon of three types of indigenous edible wild mushrooms grown in Tanzania and their utilization prospects. African Journal of Food Agriculture, Nutrition and Development 7(6).

Musieba F, Okoth S, Mibey RK, Wanjiku S, Moraa K. 2013 – Proximate composition, amino acids and vitamins profile of *Pleurotus citrinopileatus* Singer: an indigenous mushroom in Kenya. American Journal of Food Technology 8(3), 200–206.

Muthu N, Shanmugasundaram K. 2016 – Proximate and mineral compositions of edible mushroom *Cyclocybe aegerita*.

Nagai T, Inoue R, Inoue H, Suzuki N. 2003 – Preparation and antioxidant properties of water extract of propolis. Food Chemistry 80, 29–33.

Nakalembe I, Kabasa D, Olila D. 2015 – Comparative nutrient composition of selected wild edible mushrooms from two agroecological zones, Uganda. African Journal of Animal and Biomedical Sciences 4, 433.

Nanglihan KEMV, Dulay RMR, Kalaw SP. 2018 – Myko-actives and functional activities of Philippine wild mushroom *Trametes elegans*. International Journal of Biosciences. 13: 5, 402–408.

Ngai PHK, Zhao Z, Ng TB. 2005 – Agrocybin, an antifungal peptide from the edible mushroom *Agrocybe cylindracea*. Peptides 26(2), 191–196. Doi 10.1016/j.peptides.2004.09.011

O'Neil CE, Keast DR, Fulgoni VL, Nicklas TA. 2012 – Food sources of energy and nutrients among adults in the US: NHANES 2003–2006. Nutrients. 4, 2097–2120.

Palacios I, Lozano M, Moro C, D'Arrigo M et al. 2011 – Antioxidant properties of phenolic compounds occurring in edible mushrooms. Food Chemistry 128, 674–678.

Panche AP, Diwan AD, Chandra SR. 2016 – Flavonoids: an overview. Journal of Nutritional Science 5(4), 1–15.

Phan CW, Wong WL, David P, Naidu M, Sabaratnam V. 2012 – *Pleurotus giganteus* (Berk.) Karunarathna & K.D. Hyde: Nutritional value and in vitro neurite outgrowth activity in rat pheochromocytoma cells. Phan et al. BMC Complementary and Alternative Medicine 12, 102.

Pietta PG. 2000 – Flavonoids as antioxidants. Journal of Natural Products. 63(7), 1035–1042.

Puri M. 2017 – Food bioactives, extraction and biotechnology applications. Bioactive sources: plants, mushrooms and fungi. Springer.

Raneses MM, Dulay RMR, De Leon AM. 2016 – Proximate nutritive composition and teratogenic effect of *Lentinus sajor-caju* collected from Banaue, Ifugao Province, Philippines. International Journal of Biology, Pharmacy and Allied Sciences 5(7), 1771–1786.

Rathee S, Rathee D, Rathee D. 2012 – Mushrooms as therapeutic agents. Brazilian Journal of Pharmacognosy 22(2), 459–474.

Rushita S, Vijayakumar M, Noorlidah A, Ameen Abdulla M, Vikineswary S. 2013 – Effect of *Pleurotus citrinopileatus* on blood glucose, insulin and catalase of streptozotocin-induced type2 diabetes mellitus rats. The Journal of Animal & Plant Sciences 23(6), 1566–1571.

Saenmuang S, Sirijariyawat A, Aunsri N. 2017 – The effect of moisture content, temperature and variety on specific heat of edible-wild mushrooms: model construction and analysis. engineering letters 25, 4.

Salamat S, Shahid M, Najeeb J. 2017 – Proximate analysis and simultaneous mineral profiling of five selected wild commercial mushroom as a potential nutraceutical. International Journal of Chemical Studies 5(3), 297–303.

Sánchez C. 2017 – Bioactives from mushroom and their application. Mushroom: structure, growth, and composition. Springer International Publishing. M. Puri (ed.), Food Bioactives.

Silva SO, Gomez Da Costa SM, Clemente E. 2002 – Chemical composition of *Pleurotus pulmonarius* (Fr.) Quel., substrates and residue after cultivation. International Journal of Brazilian Archives of Biology and Technology 45(4), 531–535.

Singh AP, Kumar S. 2019 – Applications of Tannins in Industry. Research Gate, 1–19.

Shimada K, Fujikawa K, Yahara K, Nakamura T. 1992 – Antioxidative properties of xanthan on the autoxidation of soybean oil in cyclodextrin emulsion. Journal of Agricultural and Food Chemistry 40, 945–948.

Sowndhararajan K, Joseph JM, Manian S. 2013 – International Journal of Food Properties 16(8), 1717–1729.

Sule Enyisi I, Umoh VJ, Whong CMZ, Abdullahi IO, Alabi O. 2014 – Chemical and nutritional value of maize and maize products obtained from selected markets in Kaduna State, Nigeria. African Journal of Food Science and Technology 5(4), 100–104.

Sunita M, Dhananjay S. 2010 – Quantitative analysis of total phenolic content in Adhatodavasica Nees extracts. International Journal of Pharm Tech Research 2(4), 2403–2406.

Teklit GA. 2015 – Chemical composition and nutritional value of the most widely used mushrooms cultivated in Mekelle Tigray Ethiopia. Journal of Nutrition and Food Sciences 5, 408.

Treveylan WE, Forrest RS, Harrison JS. 1952 – "Determination of yeast carbohydrates with the anthrone reagent". Nature.170 (4328), 626–627.

Tsai S, Huang S, Mau J. 2006 – Antioxidant properties of hot water extracts from *Cyclocybe cylindracea*. Food Chemistry 98, 670–677.

Ulziijargal E, Mau JL. 2011 – Nutrient compositions of culinary-medicinal mushroom fruiting bodies and mycelia. International Journal of Medicinal Mushrooms 13(4), 343–349.

Valentão P, Lopes G, Valente M, Barbosa P et al. 2005 – Quantitation of nine organic acids in wild mushrooms. Journal of Agricultural and Food Chemistry 53(9), 3626–3630.

Valverde ME, Hernández-Pérez T, Paredes-López O. 2015 – Edible mushrooms: improving human health and promoting quality life. International Journal of Microbiology 2015, 1–14.

Vieira V, Barros L, Martins A, Ferreira ICFR. 2016 – Nutritional and biochemical profiling of *Leucopaxillus candidus* (Bres.) Singer Wild Mushroom. Molecules 21, 99.

Wani BA, Bodha RH, Wani AH. 2010 – Nutritional and medicinal importance of mushrooms. Journal of Medicinal Plants Research 4(24), 2598–2604.

Wasser SP, Weis AL. 1999 – "Medicinal properties of substances occurring in higher Basidiomycetes mushrooms: Current perspectives (Review)", International Journal of Medicinal Mushrooms 1, 31–62.

Westerterp KR. 2014 – Reliable assessment of physical activity in disease: an update on activity monitors. Current Opinion in Clinical Nutrition and Metabolic Care 17, 401–406.

Wong FC, Chai TT, Tan SL, Yong AL. 2013 – Evaluation of bioactivities and phenolic content of selected edible mushrooms in Malaysia. Tropical Journal of Pharmaceutical Research 12(6), 1011–1016.

Xu JW, Zhao W, Zhong JJ. 2010 – Biotechnological production and application of ganoderic acids. Applied Microbiology and Biotechnology 87, 457–466.

Xu T, Beelman RB. 2015 – The bioactive compounds in medicinal mushrooms have potential protective effects against neurodegenerative diseases. Advances in Food Technology and Nutrition Science 1(2), 62–65.

Xue Z, Li J, Cheng A, Yu W et al. 2015 – Structure identification of triterpene from the mushroom *Pleurotus eryngii* with inhibitory effects against breast cancer. Plant Foods and Human Nutrition 70, 291–296.

Yayli N, Yilmaz N, Ocak M, Sevim A et al. 2007 – Essential oil compositions of four mushrooms: *Scleroderma verrucosum*, *Cortinarius infractus*, *Hypholama capnoides* and *Hypholama fasciculare* from Turkey. Asian Journal of Chemistry 19(5), 4102–4106.

Yıldız S, Yılmaz A, Can Z, Kılıç C, Yıldız UC. 2017 – Total phenolic, flavonoid, tannin contents and antioxidant properties of *Pleurotus ostreatus* and *Pleurotus citrinopileatus* cultivated on various sawdust. GIDA The Journal of Food 42(3), 315–323.

Yuen SM, Kalianon K, Atong M. 2014 – Effect of different drying temperatures on the nutritional quality of edible wild mushroom, *Volvariella volvacea* obtained nearby forest areas. International Journal of Advanced Research 2(5), 859–864.

Zahid K, Barua S, Haque SMI. 2012 – Proximate composition and mineral content of selected edible mushroom varieties of Bangladesh. Bangladesh Journal of Nutrition 22–23.

Zhang M, Cui SW, Cheung PCK, Wang Q. 2007 – Antitumor polysaccharides from mushrooms: a review on their isolation process, structural characteristics and antitumor activity. Trends in Food Science and Technology 18(1), 4–19.

Zhang Y, Mills GL, Nair MG. 2003 – Cyclooxygenase inhibitory and antioxidant compounds from the fruiting body of an edible mushroom, *Agrocybe aegerita*. Phytomed 10(5), 386–390.

Zhang X, Thuong PT, Min BS, Ngoc TM et al. 2006 – Phenolic glycosides with antioxidant activity from the stem bark of *Populus davidiana*. Journal of Natural Products 69(9), 1370–1373.

Zhao C, Sun H, Tong X, Qi Y. 2003 – An antitumour lectin from the edible mushroom *Cyclocybe aegerita*. Biochemical Journal 374, 321–327.