Journal of Food Science and Agricultural Technology

International peer-reviewed scientific online journal

Published online: http://rs.mfu.ac.th/ojs/index.php/jfat

Original Research Article

Nutritional and antioxidant properties of selected-commercial mushroom in Thailand

Krittalak Pasakawee*, Panida Banjongsinsiri, Nowwapan Donrung, and Jirawat Satiankomsorakrai

Expert Centre of Innovative Helath Food (InnoFood), Thailand Institute of Scientific and Technological Research (TISTR), 35 Mu.3 Technopolis, Khlong Ha, Khlong Luang, Pathum Thani, 12120, Thailand

ARTICLE INFO

Article history:

Received 31 July 2018

Received in revised form 11 October 2018

Accepted 23 October 2018

Keywords:

Selected-commercial mushroom

Nutrition

Antioxidant activity

ABSTRACT

Mushrooms, which are basically fungi, have several varieties throughout the world. In Thailand, commercial mushrooms are uniquely distinctive taste and flavor as well as widely consume increasing as foods and medicine. The drying process can be used to prolong the storage time and improve a stabilizing property of mushroom. As in this study, the selected-commercial mushroom; Phoenic oyster mushroom (*Pleurotus sajor-caju*), Bhutan oyster mushroom (*Pleurotus eous*), Tree oyster mushroom (*Pleurotus ostreatus*), Abalone mushroom (*Pleurotus cystidiosus*), Shiitake mushroom (*Lentinula edodes*), Straw mushroom (*Volvariella volvacea*), and Black tree ear mushroom (*Auricularia auricula-judae*) were investigated for their proximate compositions, total phenolic content, antioxidant activity using 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity and the inhibition of lipid oxidation by ferric thiocyanate colorimetric method (FTC). These include a fresh mushroom and a dried form using a hot air oven at 50±5°C until having 10±2% of final moisture content. The results showed that the fresh samples have a moisture contents ranging from 89.51% to 93.45% ($p<0.05$). Dried mushrooms have the high contents in protein (9.06%-39.48% dried weight) and fiber (13.93%-28.40% dried weight) but low in fat content (0.13%-1.76% dried weight) ($p<0.05$). According to the antioxidant properties, the fresh mushrooms contained 1.33-39.24 mg GAE/g dried sample of total phenolic contents, 19.9%-79.41% of DPPH radical scavenging activity and 72.22%-87.37% of lipid peroxidation inhibitory activity ($p<0.05$). Whereas the total phenolic contents of dried samples ranged from 4.27 to 92.82 mg GAE/g dried sample ($p<0.05$) with regards to the potent radical scavenging activity on DPPH radical (51.27%-91.18%), ($p<0.05$). Moreover, the higher inhibition of peroxidation in linoleic acid system was found in the dried form (41.92-78.54%) than that of fresh samples. In conclusion, the selected-commercial mushroom may have potential as natural antioxidants and be recommended in application for functional foods. The drying process using a low air is optimally alternative process for preserving the commercial mushroom properties and can extend its shelf life.

* *Corresponding author*: Tel.: +662-577-9135; fax: +662-577-915.
E-mail address: krittalak@tistr.or.th, krittalak.p@gmail.com

Published by School of Agro-Industry, Mae Fah Luang University

ISSN: 2408-1736

INTRODUCTION

Cultivated mushrooms are widely consumed in many countries as foods and medicines due to their specifically taste, flavor, and texture (Srikram and Supavanich, 2016). They are also considered to be a good source of natural components beneficial for human life such as antitumor, hypocholesterolaemic, antioxidant, antihypertensive, anti-flammatory, hypoglycemic activity because of their high nutritional values and bioactive compounds (Cheung *et al*., 2005; Tiimub *et al.*, 2015; Srikram and Supavanich, 2016). Many researchers reported that mushrooms are rich in amino acids/protein, minerals, vitamins, glycogen, sugar, ascorbic acid, including dietary fiber. Moreover, they are low in calories, sodium, fat, and cholesterol (Sanmee *et al*., 2003; Zahid *et al*., 2010; Amadi *et al.,* 2014; Bhattacharjya *et al*., 2015; Krüzselyi *et al.*, 2016). In addition to their benefit effect, some edible mushrooms have been found to be medically active in several therapies because they are rich in bioactive compounds that contain a variety of secondary metabolites including phenolic compounds, polypeptides, terpenes and steroid, especially a peptide/amino acid. However, fresh mushroom tends to easy spoil with undesirable smell, odor, color, and texture after harvested for 6-7 h (Yuen *et al*., 2014). Drying, such as sun drying, hot air dryer, is generally carried out to extend shelf life of food products. In fact, it might be impact on the nutritional or physiological of the end products. Therefore, this study aimed to analyse the selected commercial mushrooms on the physicochemical and antioxidant properties in comparison between fresh and dried mushrooms.

MATERIALS AND METHODS

Chemicals and samples

Folin-Ciocalteu's phenol reagent, gallic acid (≥99%), DPPH (2,2-diphenyl-1-picryhydrazyl), linoleic acid, phosphate buffer pH 7.0, ammonium thiocyanate, and ferrous chloride ($FeCl_2$) were purchased from Sigma-Aldrich Chemical Co., USA. Anhydrous sodium carbonate (Na_2CO_3), sodium hydroxide (NaOH), and ethanol (≥98%) were bought from Ajax Finechem, Australia. All chemicals used in this study were of analytical grade.

Seven commercial cultivated-mushrooms; Phoenic oyster mushroom (*Pleurotus sajor-caju*), Bhutan oyster mushroom (*Pleurotus eous*), Tree oyster mushroom (*Pleurotus ostreatus*), Abalone mushroom (*Pleurotus cystidiosus*), Shiitake mushroom (*Lentinula edodes*), Straw mushroom (*Volvariella volvacea*), and Black tree ear mushroom (*Auricularia auricula-judae)* were purchased from a local market in Pathum Thani province, Thailand during March-May, 2015 and 2016.

Sample preparation

The fresh samples were washed, sliced into small pieces, and dried using a hot air oven (Memmert 600, Memmert GmbH +Co.KG, Germany) at 50±2°C for 17±2 h until the moisture content had 10±2% (AOAC, 2000). The dried sample was subsequently ground using a blender to achieve the 100-mesh of mushroom powder. The mushroom powder packed in aluminum foil bags under reduced pressure and stored at -20°C until further proximate analysis.

As for the mushroom extract solution, ground mushroom sample (3 g) was dissolved with ethanol (100 mL) and placed at room temperature (30±2°C) for 10 min. The mixture was centrifuged at 12,000 rpm for 20 min, controlling temperature at 10°C. The supernatant was collected and and then stored in a refrigerator (4-10°C) and used within 24 h for antioxidant analysis.

Proximate composition analysis

Each mushroom was analyzed for chemical compositions; moisture, ash, fat, and crude fiber contents using the method of AOAC (2000). Total nitrogen content was determined by the thermal conductivity detection method using a combustion analyzer (FP-528 LECO, MI, USA). The nitrogen content was then converted to equivalent protein using the Windows®-based operating software with a default protein factor of 6.25. The carbohydrate content was determined by the difference obtained by subtracting the measured ash, fat, protein, fiber, and moisture from 100 (AOAC, 2000).

Total phenolic content (TPC) analysis

The total phenolic content (TPC) was determined by a colorimetric spectrophotometry, using gallic acid as a standard, according to the method described by Brand-Williams *et al.* (1995). The 0.1 mL of extracted mushroom sample or standard (0-100 mg/L) was added into a test tube with 2.5 mL of diluted 10-fold Folin-Ciocalteu's reagent was mixed thoroughly. Then, 2.0 mL of 7.5% (w/v) sodium carbonate was added to the mixture and mixed gently. After left sample at room temperature in darkness condition for 30 min, the absorbance at 760 nm was measured using the U2900 UV/Vis spectrophotometer (Hitachi, Japan). The absorbance of standard was plotted and calculated to obtain a linear equation of standard. TPC was expressed as milligram of gallic acid equivalents (mg GAE) per gram of dried sample weight (g).

Determination of antioxidant activity

The DPPH radical scavenging activity test was conducted by the modified method of Yang *et al.* (2002) and Cheung and Peter (2005). DPPH radical stock solution (80 μM) in methanol was prepared fresh daily. The 0.75 mL of sample solution was diluted with 4.65 mL of distilled water and mixed with 0.6 mL of DPPH solution. The mixtures were left for 30 min in the darkness at room temperature (30±2°C). The absorbance was measured at 517 nm using an UV/Vis spectrophotometer. Distilled water was used as a control instead of the sample solution. The percentage inhibition of DPPH free radical scavenging activity was computed from the absorbance of the control (Ac) and of the sample (As) as equation; %inhibition = [(Ac–Ab)×100]/Ac.

Determination of inhibitory lipid oxidation

The inhibition of lipid oxidation was conducted using ferric thiocyanate colorimetric method adapted by Larrauri *et al.* (1996) and Cheung and Peter (2005). The sample solution (0.5 mL) was mixed in test tube with 0.05M phosphate buffer (pH 7.0, 1 mL) and 2.5% (w/v) linoleic acid solution (0.5 mL). After 24 h incubation at 40°C, 0.1 mL of the mixture was diluted with 75% (v/v) ethanol (9.7 mL). Then, the mixture was added 30% (v/v) ammonium thiocyanate (0.1 mL) and 0.02M $FeCl_2$ (0.1 mL) for 3 min. The absorbance was recorded at 500 nm using an UV/Vis spectrophotometer. Only distilled water was added as the control. The inhibitory activity (%) was determined as [(Ac–Ab)×100]/Ac, where Ac = an absorbance of the control and As = absorbance of the sample.

Statistical analysis

All of the samples were carried out in triplicate. The data analyses were performed using the Microsoft EXCEL (serial number: WTY8G-F4M7J-P4T9V-9FXJK-48K4D) and reported as mean ± standard deviation. Analysis of variance (ANOVA) was done to determine the significance of the means and using Duncan's test with confidence level at 95% ($p<0.05$).

RESULTS AND DISCUSSION

The proximate composition of selected-commercial mushroom

The purpose of this present was to investigate the chemical compositions of commercial mushrooms in Thailand which was selected from cultivated mushroom varieties. From the experiment, the moisture content of all fresh mushroom samples ranged from 89.51% to 93.45%, (Data isn't shown in Table 1). Generally, the high in moisture content was contained approximately 90% of their fresh weight (Zahid *et al.*, 2010). The high content of moisture in the fresh mushrooms suggested that great must be taken handling and preservation during storage (Adedayo, 2011; Srikran and Supavanich, 2016). Due to it might be susceptible to microbial growth (especially fungi and bacteria) and enzyme activity which accelerates spoilage.

Dried cultivated-mushrooms had the high contents in protein (9.06%-39.48%) and fiber (13.93%-28.40%) but low in fat content (0.13%-1.76%), ($p<0.05$). Carbohydrate content refers to the carbohydrate source of sample due to it showed the high values in the range of 23.63%-60.23%, ($p<0.05$). Fresh shiitake mushroom had the highest protein content (38.68±0.902 g/100 g dried weight) and fat content (10.84±0.04 g/100 g dried weight), while Black tree ear mushroom had the highest carbohydrate content of 54.12±1.05 g/100 g dried weight and the least fat content of 1.28±0.00 g/100 g dried weight. In addition, Straw mushroom also exhibited the high ash content of 10.27% (fresh form) and 20.38% (dried form) as same as the high fiber content was found in Abalone mushroom (25.45%-28.40) and Phoenic oyster mushroom (24.48%-28.40%). The nutritional contents of each commercial mushroom depend on the climate difference, species, and its origin (Tiimub *et al.*, 2015; Sirikrom and Supapvanich, 2016).

These results were found to be generally a low fat content in all cultivated-mushroom samples while the protein and carbohydrate contents were moderately and highly value in all samples, respectively. This finding was agreed with the report of Sanmee *et al.*, (2003), Zahid *et al.* (2010) and Amadi *et al*. (2014). Based on these results, the nutritional value of the dried mushroom showed a higher content than the fresh form, especially the protein and fiber content. Therefore, it is suggested that the dried mushroom is a good form for consumption. However, it is necessary to process each mushroom using drying method for controlling their quality and prolong shelf life.

Table 1. Proximate composition of selected-commercial mushrooms.

No.	Mushroom sample	Ash (g/100 g dried weight)		Protein (g/100 g dried weight)		Fat (g/100 g dried weight)		Crude fiber (g/100 g dried weight)		Carbohydrate (g/100 g dried weight)	
		Fresh	Dried	Fresh	Dried	Fresh	Dried	Fresh	Dried	Fresh	Dried
1	Phoenic oyster (*Pleurotus sajor-caju*)	5.94±0.02^{bc}	7.73±0.16^{c}	26.18±0.02^{c}	28.74±0.30^{d}	6.06±0.03^{b}	1.50±0.04^{ab}	24.48±0.12^{ab}	28.40±0.17^{a}	36.71±1.02^{bc}	30.26±0.13^{c}
2	Bhutan oyster (*Pleurotus eous*)	6.56±0.03^{b}	7.36±0.27^{c}	33.97±0.02^{b}	34.16±0.08^{bc}	7.62±0.03^{b}	0.90±0.0^{2b}	19.58±0.10^{bc}	13.93±0.38^{e}	32.28±0.07^{c}	39.29±0.08^{b}
3	Tree oyster (*Pleurotus ostreatus*)	5.45±0.01^{bc}	6.52±0.11^{d}	35.64±0.03^{ab}	36.41±0.28^{ab}	4.40±0.01^{c}	1.73±0.08^{a}	13.63±0.08^{c}	21.99±0.36^{b}	40.88±0.03^{b}	30.01±0.04^{c}
4	Abalone (*Pleurotus cystidiosus*)	4.58±0.04^{c}	8.13±0.15^{b}	29.27±0.04^{bc}	32.87±0.01^{c}	4.19±0.04^{c}	1.76±0.32^{a}	25.45±0.06^{a}	28.40±0.17^{a}	36.51±0.10^{bc}	25.96±0.11^{d}
5	Shiitake (*Lentinula edodes*)	5.19±0.02^{bc}	6.51±0.09^{d}	38.68±0.02^{a}	39.48±0.9^{0a}	10.84±0.04^{a}	0.98±0.21^{b}	19.85±0.06^{bc}	26.78±0.32^{ab}	25.50±0.06^{d}	23.63±1.02^{d}
6	Straw (*Volvariella volvacea*)	10.27±0.03^{a}	10.38±0.42^{a}	36.31±0.08^{ab}	39.20±0.30^{a}	1.66±0.01^{d}	0.52±0.0^{5c}	18.26±0.08^{bc}	22.84±0.69^{b}	33.51±0.18^{c}	24.35±0.15^{d}
7	Black tree ear (*Auricularia auricula-judae*)	4.67±0.01^{c}	2.82±0.15^{e}	16.35±0.05^{d}	9.06±0.09^{e}	1.24±0.00^{d}	0.13±0.04^{d}	23.63±0.05^{ab}	21.07±0.68^{b}	54.12±1.05^{a}	60.23±0.08^{a}

Different letters in the same column indicate significant difference at $p<0.05$.

Total phenolic content and antioxidant properties of mushroom extract

Polyphenol compounds are major phytochemicals of plant extracts, being present in many foods. They also are the major sources of antioxidant from nature. Total phenolic content has been investigated using the Folin–Ciocalteu method, which is simple, reproducible and has been widely used to study phenolic-based antioxidants (Huang et al., 2005). As this results, it indicated that total phenolic content of cultivated mushrooms varied largely. The total phenolic content was ranged between 1.33 and 39.24 mg GAE/g dried sample weight in the fresh mushrooms, ($p<0.05$) and in the range of 4.27 and 92.82 mg GAE/g dried sample weight in the dried mushrooms, ($p<0.05$).

Among the fresh mushrooms, Shiitake mushroom showed the highest contents of phenolic compounds (39.24±0.03 GAE g/g dried sample weight), while abalone mushroom showed the lowest contents of phenolic compounds (1.33±0.01 GAE g/g dried sample weight). These can be ranged as Shiitake mushroom > Bhutan oyster mushroom > Straw mushroom > Tree oyster mushroom > Phoenic mushroom > Black tree ear mushroom > Abalone mushroom. Among the dried form, Straw mushroom showed the highest TPC (91.82±0.05 GAE g/g dried sample weight), while Black tree ear mushroom showed the lowest TPC (4.27±0.01 GAE g/g dried sample weight). Ranking of TPC was Straw mushroom > Bhutan oyster mushroom > Phoenic mushroom > Shiitake mushroom > Tree oyster mushroom > Abalone mushroom > Black tree ear mushroom.

DPPH assay were used for antioxidant property due to its widely used and simplicity. DPPH assay measured free radical scavenging activity of antioxidants against the 2,2-diphenyl-1-picryhydrazyl (DPPH) radical. In the presence of antioxidant substance, the purple color changing of DPPH radical solution and the intensity of this change can be monitored spectrophotometer (Boonsong *et al.*, 2016; Sanchez, 2017). The results from table 2 showed the fresh cultivated-mushroom had a lower DPPH radical scavenging activity (19.9%-79.41%) than that of the dried mushroom (51.27%-91.18%), ($p<0.05$). The fresh Shiitake mushroom (91.18±0.01%) showed the highest DPPH activity, while Black tree ear mushroom showed the lowest (51.27±0.09%). In the dried mushroom, Shiitake mushroom exhibited the higher DPPH activity (91.18±0.01%) than that of Straw mushroom (85.95±0.01%) and Bhutan oyster mushroom (85.86±0.01%) as same as the study of Boonsong *et al.* (2016). The high contents of total phenolic compounds found in all mushrooms could be considered indicative of high antioxidant activity as DPPH assay (Cheung *et al.*, 2003; Boonsong *et al.*, 2016; Sanchez, 2017). The presented results found that the dried selected-commercial mushrooms which contained high total phenolic content had higher DPPH radical-scavenging activity than that of fresh mushrooms. Additionally, the inhibitory activity of lipid peroxidation was determined by the measurement of red color complex that occurring by linoleic acid oxidation. The 72.22%-87.37% of lipid peroxidation inhibitory activity was found in the fresh cultivated-mushroom, ($p<0.05$) and exhibited a lower activity in the dried form (41.92%-78.54%), ($p<0.05$). Similar result of lipid oxidation in the dried mushroom was found that Shiitake mushroom exhibited the higher FTC activity (72.22±0.13%) than that of Tree oyster mushroom (67.17±0.07%) and Abalone mushroom (57.07±0.10%), respectively (Boonsong *et al.*, 2016). As the reports of Kim et al. (2008) and Sanchez (2017), the phenolic compounds such as caffeic acid, pyrogallol, cinnamic acid, ρ-coumaric acid, naringenin, quercetin, which are the strong antioxidants, presented in all edible mushrooms.

Table 2. Total phenolic content and antioxidant properties (DPPH and FTC assays) of selected-commercial mushrooms.

No.	Mushroom sample	TPC (mg GAE/g dried weight sample)		%Inhibition of DPPH assay		%Inhibition of FTC assay	
		Fresh	Dried	Fresh	Dried	Fresh	Dried
1	Phoenic oyster (*Pleurotus sajor-caju*)	25.17±0.02^{c}	30.98±0.02^{c}	67.59±0.02^{c}	88.30±0.01^{ab}	79.60±0.07^{b}	78.54±0.03^{a}
2	Bhutan oyster (*Pleurotus eous*)	36.61±0.03^{a}	46.08±0.02^{B}	69.90±0.04^{c}	85.86±0.01^{ab}	81.92±0.05^{b}	72.12±0.11^{ab}
3	Tree oyster (*Pleurotus ostreatus*)	28.83±0.02^{b}	30.54±0.02^{c}	47.59±0.03^{e}	80.59±0.04^{b}	72.22±0.14^{c}	67.17±0.07^{b}
4	Abalone (*Pleurotus cystidiosus*)	1.33±0.01^{d}	15.57±0.02^{d}	57.23±0.03^{d}	60.45±0.49^{c}	74.85±0.02^{c}	57.07±0.10^{c}
5	Shiitake (*Lentinula edodes*)	39.24±0.02^{bc}	45.39±0.03^{b}	85.70±0.12^{a}	91.18±0.01^{a}	74.75±0.05^{c}	72.22±0.13^{ab}
6	Straw (*Volvariella volvacea*)	32.88±0.03^{a}	91.82±0.05^{a}	79.41±0.07^{b}	85.95±0.01a^{b}	87.37±0.11^{a}	63.38±0.07^{bc}
7	Black tree ear (*Auricularia auricula-judae*)	2.61±0.01^{d}	4.27±0.01^{e}	35.95±0.03^{f}	51.27±0.09^{d}	84.85±0.04^{ab}	41.92±0.05^{d}

Different letters in the same column indicate significant difference at $p<0.05$.

Basically, the drying process is being used to dehydrate moisture in food that will not be affect the quality of mushrooms as the nutrient still can be preserved (Yuen et al., 2014). From this present work, air drying using a hot air dryer at 50ºC is suitable for prolong its shelf life with a good nutritional value and biological activity. The drying using low heat air can retain their properties and quality (Ibrahim *et al.*, 2017). It is notably that the drying temperature affect the increased protein content, as the report of Ibrahim et al. (2017) and Audrey et al. (2004). Based on this study, the dried mushroom gave the higher nutritional value and biological activity than the fresh mushroom, excepting the inhibition of lipid oxidation in all dried mushrooms showed a lower than that of all fresh mushrooms. Therefore, the dried mushroom is suitable for human consumption.

CONCLUSION

This present study revealed that a hot air drying at low heat air (50°C) for 15-19 hour is optimally alternative process for preserving the mushroom nutrients and their properties and can extend its shelf life. It can be reducing a moisture content and increasing chemical contents. It is good for improving the crude fiber and protein contents using a drying process. The selected-commercial mushroom may have potential as natural antioxidants and be recommended for consumption and application in functional foods.

ACKNOWLEDGEMENTS

The authors are grateful thank Thailand Institute of Scientific and Technological Research (TISTR) for providing facilities and funding.

REFERENCES

AOAC. 2000. Official methods of analysis of AOAC International. 17th edition. Gaithersburg, MD, USA, Association of Analytical Communities.

Adedayo, M.R. 2011. Proximate analysis on four edible mushrooms. Journal of Applied Science and Environmental Management. 15(1): 9-11

Amadi, J.E., Eze, C.S. and Emeka, A.N. 2014. Survey and proximate analysis of edible mushrooms in Enugu State, Nigeria. 2(3): 52-57.

Audrey, M., Audia, B. and Olive-Jean, B. 2004. Effect of processing on nutrient content of foods. Food Safety. 3(37):160-164.

Bhattacharjya, D.K., Paul, R.K., Miah, Md.N. and Ahmed, K.U. 2015. Comparative study on nutritional composition of Oyster mushroom (*Pleurotus ostreatus* Fr.) cultivated on different sawdust substrates. Bioresearch communications. 1(2): 93-98.

Boonsong, S., Klaypradit, W. and Wilaipun, P. 2016. Antioxidant activities of extracts from five edible mushrooms using different extractants. Agriculture and Natural Resources. 50: 89-97.

Brand-Williams, W., Cuvelier, M.E. and Berset, C. 1995. Use of a free radical method to evaluate antioxidant activity. Lebensm.-Wiss.u.-Technol. 28: 25-30.

Cheung, L.M., Cheung Perter, C.K., and Ooi Vincent, E.C. 2003. Antioxidant activity and total phenolics of edible mushroom extracts. Food Chemistry. 81: 249-255.

Cheung, L.M. and Peter, C.K. 2005. Mushroom extracts with antioxidant activity againt lipid peroxidation. Journal of Food Chemistry. 89: 403-409.

Kim, M.H., Seguin, P., Ahn, J.K., Kim, J.J., Chun, S.C., Kim, E.H., Seo, S.H., Kang, E.Y., Kim, S.L., Park, Y.J., Ro, H.M. and Chung, I.M. 2008. Phenolic compound concentration and antioxidant activities of edible and medicinal mushroom from Korea. Journal of Agricaltural and Food chemistry. 56(16): 7265-7270.

Krüzselyi, D. Kovács, D. and vetter, J. 2016. Chemical analysis of king oyster mushroom (*Pleurotus eryngii*) fruit bodies. Acta Alimentaria. (1): 20-27.

Ibrahim, T.A., Adaramola-Ajibola, K.M., Adesuyi, A.T., Olanrewaju, S.O. and Akinro, E.B. 2017. Effect of pre-treatment and drying methods on the chemical quality and microbials density of wild edible oyster mushroom. Archive of Food and Nutritional Science.1: 39-44.

Larrauri, J. A., Rupérez, P. and Saura Calixto, F. 1996. Antioxidant activity of wine pomace. Journal of American Society for Enology and Viticulture. 47: 369-372.

Sanchez, C. 2017. Reactive oxygen species and antioxidant properties from mushrooms. Synthetic and Systems Biotechnology. 2: 13-22.

Sanmee, R., Dell, B., Lumyong, P., Izumori, K. and Lumyong, S. 2003. Nutritive value of popular wild edible mushroom from northern Thailand. Journal of Food chemistry. 82: 527-532.

Srikram, A. and Supavanich, S. 2016. Proximate compositions and bioactive compounds of edible and wild and cultivated mushroom from Northeast Thailand. Agriculture and Natural Resources. 50: 432-436.

Tiimub, B.M., Kuffour, R.A., Agyemang, T.S. and Issahaku, A. 2015. Comparative analysis of the proximate values of wild and cultivated mushrooms available in the Ghanaian markets. Interlink Continental Journal of Biological Sciences. 1(1): 1-9.

Yang, J.H., Lin, H.C. and Mau, J.L. 2002. Antioxidant properties of several commercial mushrooms. Food Chemistry. 77: 229-235.

Yuen, S.K., Kalianon, K. and 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, Md.K., Barua, S. and Haque S.M.I. 2010. Proximate composition and mineral content of selected edible mushroom varieties of Bangladesh. Bangladesh Journal of Nutrition. 61-68.