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Nutritional Security: Carbohydrate Profile and Folk Remedies of Rare Edible Mushrooms to Diversify Food and Diet: Thailand Case Study

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Abstract: The aim of this study was to explore the current knowledge and practice of agrobiodiversity to improve nutrition and health. The study focused on wild mushrooms commonly consumed in Northeastern Thailand in terms of ecology, cooking and preservation methods, and folk remedies. The monosaccharide, sugar alcohol, glucan, and carbohydrate polymer content and the glycemic index of these wild mushrooms were determined using the enzymatic method. The mushrooms collected belonged to three biological groups and were mostly saprotrophic and symbiotic. The most abundant mushrooms were *Amanita*, *Boletus*, and *Russula*, followed by *Calostoma* sp., *Astraeus asiaticus* C. Phosri, and *Astraeus odoratus* C. Phosri. Wild edible mushrooms can be used for food and medicinal purposes. Cooking methods utilized in the area consist of steaming, boiling, and grilling. Glucose was the major monosaccharide detected in all mushroom samples. Xylitol and inositol were found in all mushroom samples, while some contained mannitol and arabitol. Glucan was present in all mushroom samples, ranging from 8.03 to 31.1 mg/g DW. All mushrooms were classified as having a low glycemic index. These findings provide important information to potentially enhance and promote the utilization of wild mushrooms to improve the accessibility, availability, and sustainability of nutritious food.

Keywords: carbohydrate; glucan; mushrooms; food security; sustainability

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1. Introduction

Wild mushrooms are nutrient-rich and versatile, representing a new nutritious and delicious popular global food resource. They are rich in proteins, vitamins, fiber, and minerals, with low fat content. Edible mushrooms have been used in several cuisines in many forms, including fresh, dried, and processed, due to their unique and delicate flavor [1]. Recently, mushrooms have been proven to exhibit medicinal effects in animal study models and clinical trials. They have various health benefits and preventative properties, including anti-inflammatory, anti-tumor, anti-cancer, anti-obesity, hepato-protective, and even anti-depressive [2]. Mushrooms contain a high amount of protein with an average value of 23.80 g/100 g dry weight (DW) and complete essential amino acids [3]. Among the numerous health benefits associated with the consumption of mushrooms is the characterization of their carbohydrate profiles. Carbohydrates are also the most abundant mushroom components, usually accounting for approximately 35–70%, including digestible and non-digestible forms. Digestible carbohydrates include monosaccharides, disaccharides, and sugar alcohols. Among sugar alcohols, arabitol, mannitol, and trehalose occur naturally and are widely distributed in mushrooms [4]. Non-digestible carbohydrates, especially polysaccharides, are related to prebiotic activity. Mushroom polysaccharides are structural components of their cell walls and can be divided into two major types: rigid fibrillars of

chitin and the more abundant glucans, which include β-glucans with variable proportions of β-1,3 and β-1,6 linkages, as well as α-1,3-glucans [5].

Our research group has been interested in the carbohydrate profile, estimated glycemic index (eGI), and folk remedies of wild mushrooms commonly consumed in Northeastern Thailand, one of the Asian regions with greater wild mushroom diversity, particularly *Russula* sp., *Amanita aff.* sp., *Calostoma* sp., *Boletus griseipurpureus*, and *Astraeus odoratus* [6]. Some researchers have reported the nutritional compositions of these wild mushrooms, but there are no studies on their individual compositions in terms of monosaccharides, disaccharides, sugar alcohols, and glucans and their glycemic indexes, which significantly influence blood glucose levels [7]. Some types of mushrooms are region-specific. This is due to different climates, soil types, patterns of rain, and seasons, resulting in differences in growth, which influence their fruiting bodies and mycelia [8].

Wild mushroom consumption varies from country to country and is also influenced by culture and beliefs. For example, African countries do not utilize *Agarigus* species, while Asian countries do. In addition, the cooking methods and traditional medicine properties vary. The knowledge of medicinal usage is based on trial and error and not supported by well-documented systematic research. While some plant knowledge has been lost due to environmental degradation and changes in modern social and economic systems, it is essential that traditional knowledge passed down for more than 50 years, including cooking methods to reduce bitterness and preservation methods, be maintained. This knowledge could be applied and transformed into modern practices.

The enzymatic carbohydrate analysis method has been well established, and several analysis kits are commercially available. The kits enable rapid analysis and reduce the usage of complicated instruments. Therefore, in off-field work, the implementation of an enzyme kit with a proper calibration standard is simple and suitable for the carbohydrate analysis of mushrooms in rural areas. This can be carried out near the mushroom harvest site to reduce the transportation time, thereby influencing mushroom compound degradation.

It is important to gather information on mushroom diversification, including nutrients and folk remedies. For example, *Calostoma* spp. is a rare and region-specific scleroderma-toid fungi, despite its placement within the ectomycorrhizal sclerodermatoid fungi in evolutionary trees.

Therefore, the aim of this paper is to obtain information on the knowledge and practice of wild mushrooms commonly consumed in Northeastern Thailand in terms of ecology, cooking and preservation methods, folk remedies, and sugar profiles. The data obtained will add to the existing knowledge and documentation on folk remedies. In addition, they can serve as a valuable resource for nutritional policy planning, as a reference database, and for the identification new mushroom species for consumption, as well as for developing food-based approaches to enhance nutrition.

2. Materials and Methods

2.1. Samples

Samples of *Russula delica* Fr. (Hed Kai-Khao), *Russula virescens* (Schaeff.) Fr. (Hed Kai-kiew), *Calostoma* sp. (Hed Ta-lo), *Russula cyanoxantha* (Schaeff.) Fr. (Hed Na-lae), *Boletus griseipurpureus* Cor. (Hed Sa-med), *Amanita princeps* Corner & Bas. (Hed Rangok), *Astraeus asiaticus* C. Phosri (Hed Por-fai), and *Astraeus odoratus* C. Phosri (Hed Por-nung) were collected from Dong Yai community forest, Hua Taphan District, Amnat-Charoen Province, Thailand, in the wet season (June–September) of 2016. The mushrooms were selected based on consumption frequency by villagers. All samples were lyophilized (lyophilizer from GEA Freeze-Drying Equipment, Köln, NW, Germany) and ground (Philips 600W from Philips Electronic Co., Ltd., Jakarta, Indonesia). Powder samples were kept in vacuum aluminum foil bags at −20 °C until analysis.

2.2. Data Collection

Professional pictures were used to aid mushroom identification since several fungi had very similar morphologies. To conduct this survey, a detailed questionnaire was distributed to elaborate on the main topics: local name, ecology, cooking and preservation method, and folk remedies. Interviews were conducted with 45 villagers who had completed a questionnaire (male and female), aged between 31 and 90 years old. The study was exempt from ethics approval due to the minimal risk involved. Informed consent was obtained from all subjects involved in the study.

2.3. Monosaccharide Analysis

An enzymatic assay, K-MANGL, was performed according to the protocol provided by Megazyme (Wicklow, Ireland). In brief, a dried sample weighing 100 mg was placed into a tube, mixed with 80% ethanol, and shaken slowly. The mixture was then placed in a water bath at 80 °C for 15 min and subsequently centrifuged for 10 min at 10 °C (rpm 4600). The supernatant was transferred to a new tube, mixed with 60% (*v*/*v*) sulfuric acid, and stirred continuously with a magnetic bar for 1 h at 100 °C. The heat mixture was reacted with NADP+/ATP (nicotinamide-adenine dinucleotide phosphate + adenosine triphosphate), HK/G-6-PDH (hexokinase + glucose-6-phosphate dehydrogenase) and PGI (phosphoglucose isomerase), respectively, and then measured at a wavelength of 340 nm (Megazyme kit).

2.4. Sugar Alcohol Analysis

The enzymatic assay, D-Mannitol, K-SORB, and K-INOSL, was performed according to the protocol provided by Megazyme. In brief, a dried sample weighing 100 mg was placed in a tube and mixed with ice-cold perchloric acid (1 M) and then centrifuged at 10 °C for 10 min (rpm 4600) to obtain only a clear supernatant with the pH adjusted to 7. Then, a pipette of 0.01 mL supernatant was placed into 96-well plates, mixed with NAD+/INT (nicotinamide-adenine dinucleotide + iodonitrotetrazolium chloride) and diaphorose enzyme and SDH (sorbitol dehydrogenase), respectively, and the mixture was measured at a wavelength of 492 nm.

2.5. Glucan and Carbohydrate Polymer Analysis

The alpha-glucan, beta-glucan, cellulose, and arabinose xylan content were determined using a Megazyme kit. In brief, a sample weighing 100 mg was placed in a test tube. It was extracted with 2 mL of potassium hydroxide (2 M) solution using a magnetic stirrer for 20 min. Then, 8 mL (1.2 M, pH 3.8) of sodium acetate buffer solution and 0.2 mL enzyme (amyloglucosidase (1630 U/mL) + invertase (500 U/mL) were added and the mixture was incubated at 40 °C for 30 min. An extracted sample of 0.01 mL was then pipetted into 96-well plates. The absorbance was measured at a wavelength of 510 nm after being mixed with GODPOD reagent to determine the concentration by comparing the absorbance value to the standard glucose solution graph (Megazyme assay, K-BGLU).

2.6. Estimated Glycemic Index Analysis

The in vitro starch digestibility was assessed according to Chaipati et al., 2018 [9].

2.7. Statistical Analysis

All the values shown represent the mean averages of triplicate determinations and the data reported as the means and standard errors of the mean (mean ± SEM). The area under the curve associated with a change in the glucose level was calculated using GraphPad Prism version 5.01 (GraphPad Software, CA, USA).

3. Results

3.1. Ecology, Cooking and Preservation Methods, and Folk Remedies

According to the survey, 72% of females, 11% of males, and 17% of villagers who preferred not to disclose their gender, aged from 31 to 90 years old, participated in the interviews. Table 1 presents a complete list of wild edible mushrooms with their local names in the Thai language, ecology, cooking and preservation methods, and folk remedies. The mushrooms collected for this study belonged to three biological groups and were mostly saprotrophic and symbiotic. The mushrooms were collected from dead wood and leaves, litter-mixed soil, and their partner trees in a prospected forest. For example, *Boletus griseipurpureus* Cor. was collected from under a eucalyptus tree. Moreover, the survey showed *Amanita*, *Boletus*, and *Russula* to be the most abundant mushrooms, followed by *Calostoma* sp. (stalked puffball shape), *Astraeus asiaticus* C. Phosri, and *Astraeus odoratus* C. Phosri (barometer earthstar shape).

Table 1. Local name, ecology, cooking and preserving methods, and folk remedies of wild edible mushrooms in Amnat-Charoen Province, Thailand.

Scientific Name	Local Name	Ecology/Host	Cooking Method	Preservation Method	Folk Remedies
Russula delica Fr.	Hed Kai-khao	Near a large tree and on the sand	Boiling, steaming, used in salad, mixed with chili paste	Either grill, steam, or boil and keep in the fridge	Cancer prevention
Russula virescens (Schaeff.) Fr.	Hed Kai-kiew	On the ground and in the furrow	Boiling, steaming, used in salad, mixed with chili paste	Either grill, steam, or boil and keep in the fridge	Cancer prevention
Calostoma sp.	Hed Ta-lo	On the ground, near rotten leaves and wetland	Eaten raw, boiling, mixed with chili paste	Either wash or boil and keep in the fridge	Hypertension and cancer prevention, reduce aphthous ulcers
Russula cyanoxantha (Schaeff.) Fr.	Hed Na-lae	Along the ground beside the brook, lowland, under shade	Boiling, steaming, used in salad, mixed with chili paste	Either grill, steam, or boil and keep in the fridge	Cancer prevention, used as a laxative
Boletus griseipurpureus Cor.	Hed Sa-med	In the shade, especially under a eucalyptus tree or in a clay area	Need to boil with guava or tamarind leaves, then cook in a similar way as *Russula delica* Fr.	Boil and keep in the fridge	Diabetes and cancer prevention, used as a laxative
Amanita princeps Corner & Bas.	Hed Ra-ngok khao	On the ground under a large tree and in the shade	Boiling, steaming, used in salad, mixed with chili paste	Either grill, steam, or boil and keep in the fridge	Used as a laxative
Astraeus asiaticus C. Phosri	Hed Por-fai	Sandy land, clay, or burned soil and growing along the base of the tree	Eaten raw, boiling, mixed with chili paste	Either steam or boil and keep in the fridge	Prevent eye muscle degeneration, used as a laxative
Astraeus odoratus C. Phosri	Hed Por-nung	Loam soils, historically with a fire under the shade of rice paddies	Boiling, steaming, used in salad, mixed with chili paste	Either steam or boil and keep in the fridge	Prevent eye muscle degeneration, used as a laxative

Calostoma spp. resembles a golf ball with a jelly-like fruiting body. It poses a very interesting polysaccharide that is a gel without gelation and with no heat required. *Astrause asiatius* and *Astraeus odoratus* are puffball mushrooms similar to *Pisolithus* and *Scleroderma*, with the exception that they are subterranean fungi since they can be found underground. Traditional cooking methods such as boiling and steaming are preferred for these mushroom types. The preservation methods were similar for all mushrooms, including grilling, boiling, or steaming before being kept in the fridge.

3.2. Monosaccharide Content

The content of glucose (Table 2) in these mushrooms ranged from 2 to 5 g, higher than the 1–2 g reported by Sanmee et al., 2003 [10]. The glucose content was found in the following order: *Russula delica* Fr. > *Astraeus asiaticus* C. Phosri > *Russula virescens* (Schaeff.) Fr. > *Boletus griseipurpureus* Cor. > *Russula cyanoxantha* (Schaeff.) Fr. However, no glucose was found in *Calostoma* sp., *Amanita princeps* Corner & Bas. and *Astraeus odoratus* C. Phosri.

Table 2. Monosaccharide and sugar alcohol content of wild edible mushrooms in Amnat-Charoen Province, Thailand.

Mushrooms	Content mg/g Dry Basis										
	Glucose	Fructose	Mannose	Mannitol	Sorbitol	Xylitol	Arabitol	Inositol	α-Glucan	β-Glucan	Estimated GI
Russula delica Fr.	56.4 ± 1.5 ^{e}	nd	2.80 ± 0.4 ^{a}	26.2 ± 0.42 ^{a}	0.09 ± 0.00 ^{c}	0.08 ± 0.00 ^{c}	21.9 ± 0.35 ^{a}	1.01 ± 0.02 ^{e}	1.76 ± 0.04 ^{c}	27.0 ± 0.08 ^{e}	29 ± 0.01 ^{b}
Russula virescens (Schaeff.) Fr.	32.0 ± 0.24 ^{c}	nd	4.3 ± 0.0 ^{a}	38.3 ± 0.75 ^{d}	0.17 ± 0.01 ^{e}	0.14 ± 0.00 ^{e}	32.0 ± 0.62 ^{d}	1.17 ± 0.01 ^{ef}	2.08 ± 0.02 ^{d}	20.0 ± 0.02 ^{d}	37 ± 0.01 ^{e}
Calostoma sp.	nd	3.90 ± 0.3 ^{c}	49.1 ± 0.47 ^{d}	nd	0.03 ± 0.00 ^{a}	0.02 ± 0.00 ^{a}	nd	0.71 ± 0.00 ^{a}	1.03 ± 0.03 ^{a}	7.0 ± 0.04 ^{a}	29 ± 0.01 ^{b}
Russula cyanoxantha (Schaeff.) Fr.	23.6 ± 0.6 ^{a}	1.22 ± 0.12 ^{a}	6.76 ± 0.30 ^{b}	28.3 ± 1.14 ^{b}	0.30 ± 0.00 ^{a}	0.25 ± 0.00 ^{f}	23.6 ± 1.17 ^{b}	0.92 ± 0.01 ^{cd}	2.38 ± 0.01 ^{e}	27.1 ± 0.10 ^{e}	31 ± 0.01 ^{c}
Boletus griseipurpureus Cor.	30.0 ± 1.8 ^{b}	nd	8.82 ± 1.15 ^{c}	36.0 ± 0.50 ^{c}	0.15 ± 0.00 ^{d}	0.12 ± 0.00 ^{d}	30.0 ± 0.35 ^{c}	0.97 ± 0.01 ^{d}	1.72 ± 0.01 ^{c}	17.2 ± 0.13 ^{b}	33 ± 0.01 ^{d}
Amanita princeps Corner & Bas.	nd	nd	4.44 ± 0.20 ^{a}	nd	0.10 ± 0.00 ^{c}	0.08 ± 0.00 ^{c}	nd	0.81 ± 0.01 ^{b}	4.42 ± 0.05 ^{f}	19.2 ± 0.17 ^{c}	33 ± 0.01 ^{d}
Astraeus asiaticus C. Phosri	35.6 ± 1.9 ^{d}	2.93 ± 0.3 ^{b}	nd	42.6 ± 0.32 ^{e}	0.16 ± 0.00 ^{de}	0.13 ± 0.00 ^{de}	35.6 ± 0.33 ^{e}	0.88 ± 0.00 ^{b}	1.53 ± 0.01 ^{b}	29.6 ± 0.14 ^{f}	26 ± 0.01 ^{a}
Astraeus odoratus C. Phosri	nd	nd	8.96 ± 0.15 ^{c}	62.0 ± 0.81 ^{f}	0.05 ± 0.00 ^{b}	0.04 ± 0.00 ^{b}	nd	0.80 ± 0.00 ^{b}	2.37 ± 0.02 ^{e}	27.0 ± 0.03 ^{e}	27 ± 0.01 ^{a}

The detection limit is lower than 0.01 mg/g; nd = not detected; the data were reported as the means and standard errors of the mean (mean ± SEM). Superscript letters show a significant difference between mushroom varieties.

3.3. Sugar Alcohol Content

The results indicated that the sugar alcohol content was different in all mushroom samples (Table 2). Sorbitol, xylitol, and inositol were detected in all mushrooms. However, the amount detected was low. The content of sorbitol, xylitol, and inositol ranged from 0.03 to 0.30, 0.02 to 0.25, and 0.71 to 1.17 mg/g DW, respectively. In this study, the mannitol content ranged from 26.20 to 62.0 mg/g DW. *Astraeus odoratus* C. Phosri showed the highest mannitol content (62 mg/g DW), while *Russula delica* Fr. had the lowest (26.20 mg/g DW). Drying and freezing during sample preparation can cause a decrease in mannitol. Arabitol was not present in *Calostoma* sp., *Amanita princeps* Corner & Bas., and *Astraeus odoratus* C. Phosri. These results were similar to those reported by Sanmee et al., 2003 [10]—namely, no arabitol was detected in *Astraeus*. Regarding differences in the same species, *Astraeus odoratus* C. Phosri had the highest mannitol content, while *Astraeus asiaticus* C. Phosri had the highest amount of arabitol. Overall, *Astraeus asiaticus* C. Phosri contained the highest amount of sugar alcohol, followed by *Russula virescens* (Schaeff.) Fr.

3.4. Glucan and Carbohydrate Polymer Content

Beta- and alpha-glucan were found in all mushroom samples (Table 2). The mushroom species with the highest alpha-glucan content was *Amanita princeps* Corner & Bas, which has a strong structure and can easily be dissolved in water due to its water-soluble nature. *Astraeus asiaticus* C. Phosri had the highest β-glucan content (29.6 mg/g DW), followed by *Russula cyanoxantha* (Schaeff.) Fr., *Astraeus odoratus* C. Phosri, and *Russula delica* Fr. (27.1, 27.0 and 27.0 mg/g DW), respectively.

3.5. Estimated GI in Mushrooms

All mushrooms have a low glycemic index (GI), ranging from 25 to 37 (Table 2) and should, therefore, be suitable for people who wish to control their blood sugar because the sugar hydrolysis rate is very low. Moreover, the GI showed a similar trend as the total sugar content in the mushrooms. The trend of total glucose content (Table 2) was *Russula delica* Fr. > *Astraeus asiaticus* C. Phosri. and the GI range was *Russula delica* Fr. (30.3) > *Astraeus asiaticus* C. Phosri. (25.6). This indicated that the higher the total monosaccharide content, the higher the GI index. The carbohydrate matrix in each mushroom plays an important role in the degree of sugar hydrolysis. High glucan content can slow down sugar hydrolysis. Therefore, edible mushrooms provide sufficient sugar but a low GI.

4. Discussion

4.1. Ecology, Cooking and Preservation Methods, and Folk Remedies

The edible parts of mushrooms are mostly the cap, gill, and stem. Wild edible mushrooms can be collected by persons of any gender or age. The findings of this study reveal that the level of knowledge exhibited by these collectors varies from one respondent to another. In fact, the older age group is associated with greater knowledge of wild edible mushrooms. The information provided by the respondents indicated that wild edible mushrooms can be used for both food and medicinal purposes, which is in accordance with the findings of Kumla et al., 2023 [11]. *Amanita* mushrooms are the most abundant, followed by *Boletus* and *Russula* spp. Some mushrooms (*Calostoma* sp.) can be eaten raw, while others, such as *Boletus griseipurpureus* Cor., cannot because they might cause nausea, vomiting, cramps, or diarrhea. Therefore, the most popular cooking methods for these mushrooms are boiling and steaming; they are then used in salads and mixed with chili paste. *Boletus griseipurpureus* Cor. needs to be boiled together with guava or tamarind leaves to reduce the bitter and astringent taste, which is possibly due to the alkaloid content present [12]. Since mushrooms are highly perishable, an effective preservation method is needed to extend their shelf life. Most mushrooms are passed through a heating process involving either steaming or boiling and then kept in the fridge or freezer. However, *Calostoma* sp. can be kept immediately after washing. These cooking methods have been proven to retain bioactive compounds such as phenolics and vitamin C [13], which are linked to folk remedies for cancer prevention. Regarding their medicinal properties, according to the beliefs passed down the generations, mushrooms exhibit anti-cancer and anti-hypertension properties. This concurs with the findings of Nandi et al., 2013 [14], who reported that *Russula* spp. exhibits immunomodulation activity, which could be linked to cancer prevention. Moreover, some mushrooms demonstrate health benefits such as laxative properties and prevention against eye muscle degeneration. This might be due to the terpene or terpenoid compounds contained in mushrooms, such as *Pleurotus cornucopiae* and *Flammulina velutipes* [15]. *Russula* spp. is known for its ability to produce color pigments (red, yellow, purple, brown, and blue or a mixture of all). The pigments are from laccase and ligninase enzymes that can degrade complex polyphenolic compounds such as lignin. Hence, *Russula* spp. can absorb digested phenolic nutrients from host debris [8], which also includes pigment compounds.

4.2. Monosaccharide Content

In general, the monosaccharide compounds found in mushrooms include glucose, mannose, galactose, xylose, arabinose, rhamnose, and fructose. However, the monosaccharide content in mushrooms is lower than in other fruits and vegetables. The findings of this study revealed that *Calostoma* sp. contained the highest amount of fructose, followed by *Astraeus asiaticus* C. Phosri and *Russula cyanoxantha* (Schaeff.) Fr., while mannose was detected in all species except *Astraeus asiaticus* C. Phosri. Mannose is a type of sugar with good water solubility properties. It is part of the glucan structure of mushrooms. Therefore, in mushrooms that contain mannose, glucan will subsequently be detected. However, mushrooms containing glucan may not have mannose as subunit molecules,

such as *Astraeus asiaticus* C. Phosri. Singdevsachan et al., 2016 [16] reported that galactose and arabinose might be included in the glucan structure of *Astraeus asiaticus* C. Phosri. In similarity to [17], no xylose was detected in any mushrooms in the current study. However, some researchers have found xylose in mushrooms such as *Lentinula edodes* and certain species of *Ganoderma*. The lack of monosaccharide detection might be because it is present as heteropolysaccharide, and a medium amount of variation exists at the site of the fruiting body [18].

4.3. Sugar Alcohol Content

The lack of xylitol detection in mushrooms in this study contradicts the findings of [19], which revealed that xylitol is only a specific marker for edible *Suillus bovinus* mushrooms. However, this could be due to the environmental growth of the mushroom. Moreover, the amount of inositol detected in *Astraeus asiaticus* C. Phosri and *Astraeus odoratus* C. Phosri in this study was higher than that reported by Sanmee et al., 2003 [10]. This might be due to the hydrolysis of xylose, causing an increase in inositol. Mannitol and arabitol were detected at high concentrations in all mushrooms except *Calostoma* sp. and *Amanita princeps* Corner & Bas. Mannitol is a major sugar alcohol identified in mushrooms, participating in the growth and firmness of the fruiting body. The variation depends on environmental factors such as pH, carbon, and nitrogen availability [2].

4.4. Beta- and Alpha-Glucan Is Complex

Carbohydrates act as a shield and structure for mushrooms. Alpha-glucan is part of the mushroom structure, especially at the base. Polysaccharides offer a diverse range of cellular functions, such as energy storage, cell wall structure, cell–cell interactions and signaling, host–pathogen interaction, and protein glycosylation. Hence, their content varies. Most of the glucan present in mushrooms is located in the cell wall. The middle layer of the mushroom's cell wall is composed of the beta-glucan network. However, variations in layer composition are dependent upon the species, growth conditions, and stage of maturity [20]. Beta-glucan can be accumulated in different species of mushrooms and correlated with the structure. *Astraeus asiaticus* C. Phosri has the highest amount of total glucan (29.6 mg/g DW) due to its hard structure, while the cell wall of *Calostoma* sp. is softer and smoother, resulting in only 7 mg/g DW of beta-glucan. Higher amounts of beta-glucan result in lower water solubility and prevent the spread of mushroom spores. The beta-glucan content of *Russula cyanoxantha* (Schaeff.) Fr. found in this study was similar to that reported by [21], which was 0.29 mg/g DW, while the beta-glucan content of *Russula delica* Fr. found in this study (29 mg/g) was lower (38 mg/g).

4.5. Nutrition Security Perspective

Wild mushrooms can be effectively utilized as a good food source to support nutrition security. They are rich in complex, single polysaccharides and protein, as well as vitamins and minerals. The community has been consuming mushrooms for decades through traditional beliefs. The high biodiversity in Northern Thailand provides access to various nutrients in terms of food availability. In addition, wild mushrooms are naturally abundant in the area, especially during the rainy season, when most food is scarce due to flooding and the lack of transportation.

5. Conclusions

All mushrooms collected from Dong Yai community forest, Amnat-Charoen Province, Thailand, contained various levels of monosaccharides, sugar alcohols, and glucans. The chemical characteristics of mushrooms display the importance of their inclusion in the diet. Cooking and preservation methods could be used to help people to become familiar with wild mushrooms. In addition, these wild edible mushrooms provide an excellent source of beta-glucan, especially *Astraeus asiaticus* C. Phosri. The utilization of mushrooms is a good example of providing nutritional security in remote areas. The main limitation of this

study is that it was conducted on one occasion and in one area. Therefore, the sugar and carbohydrate content could change since it is influenced by the seasonal climate. Further studies on these wild mushrooms are needed to explore their potential as a functional food source. Moreover, these findings could lead to the diversification of food and the diet, as well as helping to preserve the forest as a mushroom growing area for sustainability.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. All participants were fully informed, and their anonymity was assured.

Data Availability Statement: Data are available upon request.

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