KAVAKA 60(4): 46-54 (2024) DOI: 10.36460/Kavaka/60/4/2024/46-54

Investigation of Nutritional, Nutraceutical, Antioxidant, and Antifungal Potential of Wild Edible Mushroom *Astraeus asiaticus* from Kondagaon forest, Chhattisgarh, India

Chandrahas Dewangan and Sushil Kumar Shahi*

Bio-resource Product Research Laboratory, Department of Botany, Guru Ghasidas Vishwavidyalaya, Bilaspur - 495 009, Chhattisgarh, India.

**Corresponding author Email: sushilkshahi@gmail.com*

(Submitted on November 16, 2024; Accepted on December 9, 2024)

ABSTRACT

***Astraeus asiaticus* Phosri, M.P. Martín & Watling, is a traditional food source for indigenous communities in Chhattisgarh, India. However, its nutritional and medicinal benefits have still not been explored in Chhattisgarh. This study aimed to investigate the nutritional, metabolite content, and bioprospecting potential of this gastroid mushroom. The extract of *A. asiaticus* when evaluated was found to contain carbohydrates (9.37±0.02 mg/g), protein (340±0.04 mg/g), crude fiber (10.8±0.67%), ash (4.83±0.89%), phenolic content (6.14±0.47 mg/g), flavonoids (5.73±0.15 mg/g) and ascorbic acid (5.56±0.28 mg/g). The methanolic extract of *A. asiaticus* exhibited antioxidant activity, with inhibition of 18.01±1.60%, 59.84±2.25%, 69.17±3.76%, 83.16±1.49%, and 79.86±1.50% at different concentrations. The IC50 value for radical scavenging activity was 66.50±1.90 µg/ml. The methanolic extract of *A. asiaticus* also demonstrated antifungal activity, with MICs for *Penicillium expansum* (PP758388), *Alternaria alternata* (PP789274), and *Aspergillus tamari* (PP506143) which was found to be 1.33±0.58 mg/ml, 1.33±0.29 mg/ml, and 0.83±0.29 mg/ml, respectively. The findings of this study are indicative of the possibility of the use of *A. asiaticus* as a valuable source of nutritional components, natural antioxidants, and antifungal agents, which are of immense utility in public health.**

Keywords: *Astraeus*, Bioprospection, Metabolites, Nutritional composition.

INTRODUCTION

Wild mushrooms found in forests are a natural indigenous source of nutrition and medicine for humans around the world (Boa, 2004). According to Singh (2011), about 80% of forest dwellers depend on seasonal forest products such as mushrooms for 20–25% of their annual nutritional needs. The same as cereals and beverages, wild cultivated mushrooms serve as a natural functional element of food (Barros *et al.*, 2008). Their nutritional (proteins, fatty acids, fiber, and vitamins) and bioactive components (ascorbic acid, carotenoids, phenolics, flavonoids, and tocopherols) are capable of fighting many human diseases (e.g., cardiovascular, inflammation, and cancer) (Barros *et al.*, 2008; *et al.*, 2018). Beyond nutrition and health, the use of wild and cultivated mushrooms for biomedical and industrial applications is increasing (Hyde *et al.*, 2010). With the current state of malnutrition in developing nations, nutrient-dense foods such as mushrooms can serve as a valuable supplement to a diet that meets all dietary requirements. *Astraeus* species are reported to contain moderate amounts of crude protein (14%–14.7%), high carbohydrates (44.9–54.4%), high crude fibre (10.8–12.3%), and low fat (2.7–4.4%) (Sanmee *et al.*, 2003) as well as bioactive compounds having antidiabetic, hepatoprotective, anticancer, anti-inflammatory, and cardioprotective properties (Biswas *et al.* 2017). In Chhattisgarh, the majority of the wild mushrooms which are harvested from the forest by the local population belongs to the species of *Termitomyces*, *Astraeus*, *Agaricus* and *Pleurotus*. In the present paper, results of the investigations on nutritional and nutraceutical aspects of *Astraeus asiaticus* Phosri, M.P. Martín & Watling, which is commonly gathered by the local population for personal consumption have been presented.

MATERIAL AND METHOD

Sample collection

A sample of fresh basidiocarps (1–4 cm in diam) was collected in June 2023 from the forest area of Kondagaon district (19.9732160N, 81.6071030E) located in the southern part of Chhattisgarh, India. The macro- and microscopic details of this collected mushroom were examined for identification by using standard taxonomic keys (Zeller, 1949; Phosri *et al.*, 2004). For undertaking nutritional and metabolite investigations, basidiocarps were sun-dried and powdered.

Estimation of total protein

Preparation of reagent

Reagent [A]: 2 percent sodium carbonate in 0.1 N sodium hydroxide.

Reagent [B]: 0.5 percent copper sulfate in 1 percent potassium sodium tartrate.

Reagent [C]: 50 ml of Reagent [A] + 1 ml of Reagent [B].

Quantitative analysis of protein

The total protein content in the collected sample was determined by Lowry method with certain modifications (Sudheep and Sridhar, 2014) by using bovine serum albumin (BSA) as the standard. The aqueous solution of 0.5 mg/ml BSA was taken in different concentrations (0.1 µg/ml, 0.2 µg/ml, 0.3 µg/ml, 0.4 µg/ml, and 0.5 µg/ml) in different test tubes. The volume of each of these was raised to 1 ml by adding distilled water. Dried mushroom powder (0.5 g) was homogenized in a pre-chilled mortar and pestle containing 10 ml of potassium phosphate buffer and then centrifuged at 12,000 rpm for 20 min. Then, 0.1 ml of supernatant was taken out into a test tube whose initial volume was raised to 1 ml by adding distilled water. In control, 1 ml of distilled water was taken in place of supernatant in another test tube. All the test tubes were then filled with 5 ml of reagent C and incubated for 10 min at room temperature. After incubation, 0.5 ml of Folin–ciocalteu reagent was added in each test tube and again incubated for 30 min for a proper reaction. Absorbance was measured at 660 nm spectrophotometrically. All the experiments were conducted in triplicate.

Estimation of carbohydrate

To quantify the carbohydrate content in *Astraeus asiaticus*, the aqueous extract of mushroom powder (0.5 g) was taken. Anthrone method was employed for quantification (Plummer, 1990). Anthrone reagent was prepared in a concentration of 1 mg/ml. Glucose (200 µg /ml) was taken as a standard. Subsequently, from the stock solution different concentrations (10, 20 40, 60, 80,100, 150, and 200 µg/ml) were taken in test tubes. The volume of the stock solution taken in different tubes was raised to 1 ml by adding distilled water. In control, 1 ml of distilled water was taken and 1 ml of aqueous extract of the sample was taken in 3 test tubes. Subsequently, 5 ml of the anthrone reagent was added to all tubes and mixed well by vortexing. Tubes were covered with caps and incubated at 90°C for 17 min and then cooled to room temperature. The optical density was determined at 620 nm against the control.

Estimation of crude fibre

Crude fibre content was estimated following the methodology given by Joslyn (1970), with some modifications. To prepare the sample, 2 g of mushroom powder was weighed and boiled in 200 ml of 1.25 % sulphuric acid for 40 min. After that, it was filtered and the filtrate was cleaned to remove acidic residue by washing it in boiling water. Further, the filtrate was then boiled in 200 ml of 1.25 % sodium hydroxide solution for 40 min. Again, filtered and the remaining filtrate was washed in boiling water till it became free from mixed chemicals and then finally it was rinsed with ether and ethanol. After washing, the remaining residue was transferred to a pre-weighed crucible and oven-dried at 120°C for 2 h, and then the dry weight of the remaining sample was measured. After that, the sample was then incinerated at 660°C for 30 min in a muffle furnace until a greyish-white or grey ash was obtained. It was then cooled at room temperature and reweighed. The percent of crude fibre content was calculated by using the formula:

% Crude fibre = Loss in weight on ignition / weight of the sample × 100.

Estimation of ash content

To calculate the ash content in *A. asiaticus*, three grams of powdered mushroom was heated over an oxidizing flame until the smoke become clear. Then, the sample was treated in a muffle furnace at 550°C for 6 h. After treatment, the sample was cooled in a desiccator and weighed for estimation. The following formula was used to determine the amount of ash in the sample:

Ash content (%) = (Weight of ash) g / (weight of the sample taken) g × 100.

Total phenolics content (TPC) assay

For the estimation of the presence of total phenolic content in *A. asiaticus*, Folin–Ciocalteu reagent method (McDonald *et al.*, 2001) was adopted. Gallic acid was taken as standard. For this purpose, 0.5 g of dried powder of the sample was dissolved in 5 ml of methanol and vortexed for 2 h at room temperature at 150 rpm, and then filtered through Whatman No.1 filter paper. The filtrate was

evaporated at 40°C in a water bath to get a solid precipitate and then it was again dissolved in methanol taking a concentration of 0.5 mg/ ml to make the final working solution. Briefly, 0.1 ml Folin-Ciocalteu (0.5 N) reagent and 0.5 ml working solution were added and mixed well, then incubated for 15 min at room temperature for proper reaction. After incubation, sodium carbonate solution (2.5 ml) was added to the mixture, which was again incubated at room temperature for 30 min. The absorbance was measured at 760 nm. All experiments were performed in triplicate.

Total flavonoid content (TFC) assay

Estimation of total flavonoid content in the sample was performed by using a standard guideline as suggested by Meda *et al.* (2005), with certain modifications. Quercetin was used as a standard. Methanolic extract of *A. asiaticus* was prepared by dissolving 1 g of powdered sample in 10 ml of methanol. Further, 1 ml of methanolic extract was mixed with 100 µL of 5% $NaNO_2$ and incubated for 5 min. Then, 150 µL of 2% $AlCl_3$ (prepared in absolute methanol) was added and again incubated at room temperature for 10 min. Thereafter, 200 µL of 1 M NaOH was added and vortexed for 5 min at 200 rpm then, absorbance was measured at 510 nm.

Total ascorbic acid content (TAAC) assay

To calculate the total ascorbic acid content in *A. asiaticus*, Folin-Ciocalteu reagent method suggested by Jagota and Dani (1982), was implied with certain modifications. Ascorbic acid was taken as standard. Homogenate of the sample (1 ml) was taken which was prepared by mixing 2 g of the powdered mushroom in 5 ml ethyl acetate. Then, it was mixed with 0.8 ml of 10% trichloroacetic acid and refrigerated for 5 min before centrifugation at 3000 rpm. Thereafter, 0.2 ml was retrieved from the mixture and mixed well with 1.8 ml of distilled water to make up the final volume to 2 ml. Finally, 0.2 ml of Folin-Ciocalteu was added to the diluted extract mixture. After 10 min of incubation at room temperature, the absorbance was measured at 760 nm.

Bioprospection activity

Antioxidant activity assay (DPPH assay method)

1,1-Diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity was determined using a modified method as suggested by Pandey and Ghosh (2022a). For this purpose 100 ml of 0.002% DPPH was prepared in methanol for determination of scavenging activity. In methanol 1 µg/µl concentration of gallic acid was prepared and taken as a standard. The mushroom extract was prepared by dissolving 5 g of mushroom powder in 50 ml methanol and kept overnight in a shaker at room temperature then filtered with Whatman no.1 filter paper. Filtrate was then processed in rotavapor under pressure to get powdered components. Subsequently, 5 mg of extract powder was dissolved in 5 ml methanol to make the stock solution. From the stock solution, a series of concentrations (0.1 mg/ml, 0.5 mg/ml, 1 mg/ml, 1.5 mg/ml, 2 mg/ml, and 2.5 mg/ml) were prepared in test tubes by adding distilled water to make a final concentration of 1 ml. Then 3 ml of 0.002% DPPH was pipetted into each tube and incubated in the dark for 30 min for proper chemical reaction. After incubation, the absorbance was taken at 517 nm. Methanol was kept as a control. To determine the percentage of DPPH reduction, following formula was used:

% DPPH reduction or % of DPPH inhibition = (A – B)/A × 100

where, A - Represents the absorbance of the DPPH solution in oxidized form.

B - Indicates absorbance of sample, after 30 min of reaction with DPPH.

For IC50 value, the absorbance of the methanol was taken as a control and the absorbance of the extract was used as a sample. Then, the IC50 (50% of inhibition) value was calculated by using the formula:

DPPH scavenging effect = Control OD – Sample OD/ Control OD × 100.

Determination of antifungal activity

The antifungal activity of the extract of *A. asiaticus* was determined by using CLSI guidelines for antifungal susceptibility testing method as suggested by Fothergill (2011). For this purpose, 10 g of mushroom powder was taken in 50 ml methanol in a conical flask and kept for overnight in a shaker at room temperature and filtered using Whatman no. 1 filter paper and centrifuged at 8000 rpm. The collected supernatant was evaporated through a water bath at 60°C to get the fine powder of the mushroom extract. Finally, the stock solution was prepared by dissolving 20 mg of mushroom extract in 1 ml of DMSO and kept at 4°C for further use. Similarly, fluconazole stock was also prepared by adding 10 mg fluconazole in

1 ml DMSO. Three fungal species viz., *Aspergillus tamari* (PP506143), *Alternaria alternate* (PP789274), and *Penicillium expansum* (PP758388) were used as test organisms. The quantity of inoculum for each test microorganism was standardized at a level of 1.5×10^8 CFU/ml by comparing it to 0.5 McFarland standard.

The MIC of the extract of *A. asiaticus* was determined using the microtiter dilution method with resazurin as an indicator. PDB (Potato dextrose broth) was used as a nutrient medium for test organisms. For this purpose, 100 μL of PDB was poured into each of 12 columns in each of 6 (3+3) rows (**Figure 1 and 2**) of 96 wells of the microtiterplate. Then, 100 μL mushroom extract was added to well 1 in Row A, B, and C containing the broth, and the contents were mixed and diluted in serial two fold dilutions through well 10, yielding concentrations ranging from 2 mg/ml for well 1 to 0.0039 mg/ml for well 10 (**Figure 2**). The 100 μL content supposed to be transferred to well 11 was discarded, thus no extract was added afterward. Hence, wells 11 and 12 were left with no extract and designated as positive control and negative control, respectively.

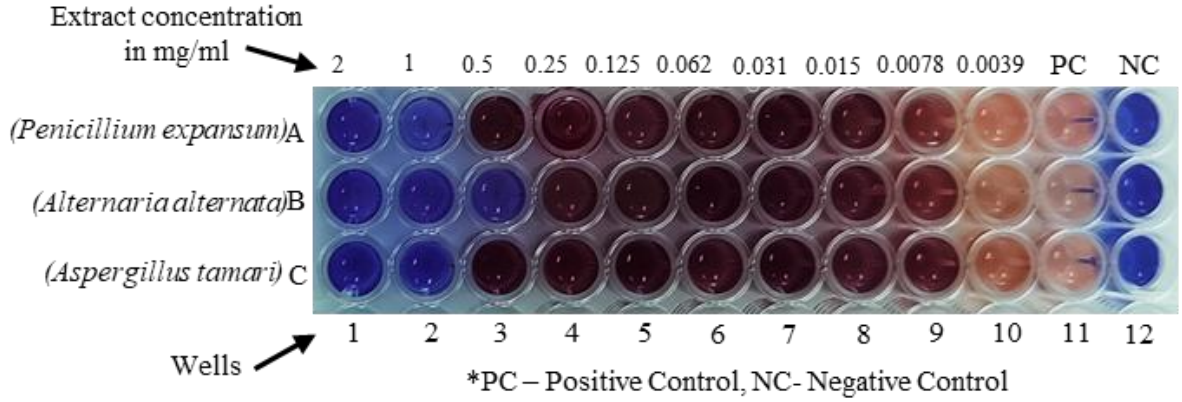

Figure 1: Determination of minimum inhibitory concentrations of the methanolic extract of *Astraeus asiaticus* against plant pathogenic fungi.

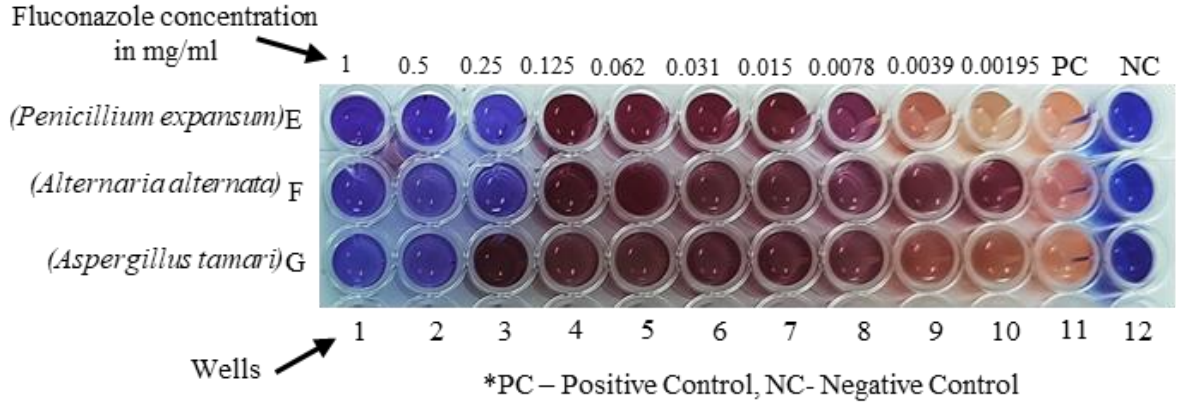

Figure 2: Determination of minimum inhibitory concentrations of fluconazole against plant pathogenic fungi.

Similarly, wells 1 through 10 in the remaining rows (rows E, F, and G) were filled with a mixture of PDB and fluconazole concentrations ranging from 1 mg/ml for well 1 to 0.00195 mg/ml for well 10, leaving the last 2 wells for positive and negative controls (**Figure 2**). With the exception, well 12 in each row, the contents of wells 1 through 11 were inoculated with 50 μL of test/target organism viz., *Penicillium expansum* (PP758388), *Alternaria alternate* (PP789274) and *Aspergillus tamari* (PP506143) in rows AD, BE and CG, respectively. The microtiter plate was sealed with parafilm and incubated at 28°C for 24 h. After the incubation period, the MIC of each test organism was detected by adding 10 μL resazurin, an indicator dye into the wells of the microtiter plate. Then, the microtiter plate was again incubated for 1 h at 28°C. The colour change of the resazurin was checked after 1 h and recorded. Biologically active fungus reduces the resazurin to colourless resazurin salt and

pinkish-red resazurin product. When solutions in the wells of the microtiter plate remained clear (without colour change), we infer that the growth of the fungus was inhibited.

RESULTS

The present study investigated the nutritional content of the wild edible mushroom *A. asiaticus*. The study revealed a substantial protein content of 340 mg/g in the dried sporocarp, as shown in **Table 1**. In addition, the total carbohydrate content was determined to be 9.37 mg/g of dried mushroom. The analysis showed a crude fiber content of 10.8% and ash content was 4.83% in the examined *A. asiaticus*. Furthermore, the methanolic extracts of *A. asiaticus* exhibited a total phenolic content of 6.14 mg of gallic acid equivalents per gram of dried mushroom. The results also indicated the presence of other beneficial compounds including a total flavonoid content of 5.73 mg/g and an ascorbic acid content of 5.56 mg/g. These findings suggest that *A. asiaticus* is a valuable source of various nutrients and nutraceutically important health-promoting compounds.

Table 1: Nutritional and nutraceutical components of *A. asiaticus* collected from Kondagaon, Chhattisgarh, India on a dry weight basis (mean ± standard deviation, n = 3).

S.No.	Assay	Result
1.	Total protein content (mg/ g)	340 ± 0.04
2.	Carbohydrate content (mg/g)	9.37 ± 0.02
3.	Crude fibre content (%)	10.8 ± 0.67
4.	Ash content (%)	4.83±0.89
5.	Total phenolic content (mg/g	6.14 ± 0.47
6.	Total flavonoid content (mg/g)	5.73 ± 0.15
7.	Ascorbic acid content (mg/g)	5.56 ± 0.28

Methanolic extract of the *Astraeus asiaticus* demonstrated a percent inhibition of a minimum of 18.01% and a maximum of 83.16% of its ability to scavenge DPPH radicals at the concentration of 0.5 mg/ml and 2 mg/ml of extract, respectively (**Table 2**). When the concentration of the extract gradually increased from 2 mg/ml, a decrease in the percentage inhibition was observed as shown in **Table 2**. The IC50 (50 % of inhibition) value of the extract was 66.50 ± 1.90 µg/ml.

Table 2: Antioxidant capacity of methanolic extract of *A. asiaticus* (mean ± standard deviation, n = 3).

S.No.	Extract concentration (mg/ml)	% Inhibition
1.	0.1	00
2.	0.5	18.01 ± 1.60
3.	1.0	59.84 ± 2.25
4.	1.5	69.17 ± 3.76
5.	2.0	83.16 ± 1.49
6.	2.5	79.86 ± 1.50

The utilization of methanolic extracts from *A. aisaticus* has yielded noteworthy antifungal efficacy against plant pathogenic fungi viz., *Penicillium expansum* PP758388, *Alternaria alternata* PP789274, and *Aspergillus tamari* PP506143 (Figure 1). In the present study, the MIC against *Aspergillus tamari* PP506143 was found to be 0.83 mg /ml, highly susceptible as compared to other targeted organisms tested (**Table 3**). *Penicillium expansum* PP758388 and *Alternaria alternata* PP789274 showed MIC at 1.33 mg/ml in methanolic extract but with fluconazole, the MIC range varied as 0.42 and 0.33 mg/ml against the pathogenic fungi *Penicillium expansum*PP758388 and *Alternaria alternate* PP789274, respectively (**Table 3**).

Table 3: Antifungal activity of methanolic extract of *Astraeus asiaticus* (mean ± standard deviation, n = 3).

S. No.	Tested organism	Fluconazole MIC (mg/ml)	Methanolic extract from mushroom MIC (mg/ml)
1.	*Penicillium expansum* (PP758388)	0.42±0.14	1.33±0.58
2.	*Alternaria alternata* (PP89274)	0.33±0.14	1.33±0.29
3.	*Aspergillus tamari* (PP506143)	0.50±00	0.83±0.29

DISCUSSION

Dried sporocarp of *Astraeus asiaticus* has been shown to have 340 mg/g of protein as shown in Table 1 while Pandey and Ghosh (2022b) reported 178 mg/g of protein for the same species collected from West Bengal. According to Pavithra *et al.* (2018), *Astraeus hygrometricus* has 168 mg/g of protein in uncooked tender and 173 mg/g in cooked one. Ayimbila and Keawsompong (2023) in a review reported 368.7 mg/g protein content in *Tricholoma* sp. Proteins are essential for cell growth and repair because they are important nutritional components that provide shape to cells, tissues, and organs. During the present investigation, total carbohydrate content in the wild edible *A. asiaticus* was found to be 9.37 mg/g on dry weight basis. On-nom *et al.* (2023) while working on the aqueous extract of *A. asiaticus* reported 29.6 mg/g β-glucan content. Pandey and Ghosh (2022b) evaluated 65.72 mg/g of carbohydrate content in *Astraeus* species from West Bengal. In comparison, the present sample of *A. asiaticus* from Chhattisgarh has a very low quantity of carbohydrates. Carbohydrate distribution in mushrooms is reported to change greatly in different regions during growth and fruiting (Zhou *et al.*, 2016). This low concentration may also be indicative of its low calorific value, which is good for diabetic patients.

In the present sample of *A. asiaticus*, 10.8 % crude fibre was found to be present. Significantly, Pandey and Ghosh (2022b) also reported 11.49% of crude fibre in *A. asiaticus* sample from West Bengal, which is comparable to the present observation made on mushroom sample from Chhattisgarh. Magrati *et al.* (2011) reported a very high content of crude fibre (28.8%) in *Morchella conica* and this proportion varies with the mushroom sample. Crude fibre is a non-digestible carbohydrate that attenuates blood glucose and lipids, among other physiological functions. It works by reducing the amount of LDL cholesterol in the blood, which helps to prevent heart problems and constipation (Barber *et al.*, 2020). Additionally, it gives the feeling of fullness, which aids in controlling weight. Therefore, adding these wild edible mushrooms to the diet would ostensibly provide a wide range of health benefits to human beings. The amount of ash in the examined *A. asiaticus* was 4.83 %, somewhat more than that of the identical species studied by Pandey and Ghosh (2022b). Similarly, Akata *et al.* (2012) reported higher amount of ash proportion (11%) in *Rhizopogon luteolus*. It is also a variable component with different mushrooms and largely depends upon the consistency of the mushroom sample.

In the present study, in the methanolic extracts of *A. asiaticus*, total phenolic content of 6.14 mg of gallic acid equivalents per gram of dried mushroom was documented. Previously, Pandey and Ghosh (2022b), while working on *A. asiaticus* reported 6.8 ± 0.15, 3.95 ± 0.15 mg GAE/g of total phenolic content in hot water, acetone etxract, and 2.16 ± 0.26 mg GAE/g in hexane extracts of the mushroom sample. In case of *A. hygrometricus*, Martínez-Escobedo *et al.* (2021) reported 1.54 ± 0.07 mg GAE/g of phenolic content which is much less in comparison to the amount of phenolic content present in the Chhattisgarh sample. In the case of *A. brasiliensis*, Bach *et al.* (2019), reported much higher amount of phenolic contents (13.16 mgGAE/g) in comparison. It is an established fact that phenolic compound-rich materials show *in vitro* antioxidant properties, including the ability to scavenge free radicals, prevent lipid peroxidation, and reduce ferrous iron (Cheung *et al.*, 2003). Certain phenolic substances are also known to increase the production of endogenous antioxidants (catalase, superoxide dismutase, and peroxidase) which helps to shield cells from the harmful effect of free radicals by scavenging their excessive amounts. In view of the presence of higher concentration of phenolic compounds in wild edible mushrooms including species of *Astraeus*, these can be effectively utilised to prevent the body from oxidative damage by dangerous free radicals that are produced during physiological stress.

With regard to total flavoniod content, the results achieved indicated that the TFC was 5.73 mg of quercetin equivalents /g of dried mushroom. In the

case of *Rhizopogon luteolus*, Altaf *et al.* (2020) reported 0.70 mg/g while Pandey and Ghosh (2022b) documented 2.76 mg/g flavonoid in *A. asiaticus* which is much less when compared to the present achieved result (Table 1). In another research on *Volvariella volvacea*, in aqueous and ethanolic extracts 7.29 ± 0.21 and 9.05 ± 0.89 mg QE/g of flavonoid content was reported, respectively by Boonsong *et al*. (2016). Significance of flavonoids is well known for their antioxidant properties (Buruleanu *et al.,* 2018). The mode of action of flavonoids involves the scavenging of reactive species, chelating trace metal ions involved in the production of reactive species, regeneration of tocopherol and a membrane-bound antioxidant inhibition of lipoxygenase enzymes.

In present investigation, 5.56 mg/g of ascorbic acid content was documented in *A. asiaticus* sample from Chhattisgarh. In the case of *Craterellus cornucopioides*, Dimopoulou *et al.* (2022) reported 0.81 mg/g DM ascorbic acid. In the case of *Laetiporus sulphureous* and *Ramaria flava*, Ozen *et al.* (2019) reported 4.10 and 5.25 mg of ascorbic acid/g, respectively. The amount of ascorbic acid in *Ramaria flava* is comparable to the present result of *A. asiaticus*. Due to its water solubility, ascorbic acid can suppress free radical activity both within and outside of cells, exhibiting antitumor characteristics, lowering the risk of cardiovascular illnesses, etc., and delaying the aging process. As a result, the chosen mushroom has a high potential for bioactivity.

DPPH is a stable free radical that exhibits idiosyncratic absorption at 517 nm. As antioxidants provide protons, the absorption of these radicals decreases. A decrease in absorbance has been verified as an indication of the degree of radical scavenging. During the present investigation, methanolic extract of the *Astraeus asiaticus* demonstrated inhibition of a minimum of 18.01% and a maximum of 83.16% of its ability to scavenge DPPH radicals at the concentration of 0.5 mg/ml and 2 mg/ml of extract, respectively. When the concentration of the extract gradually increased from 2 mg/ml, a decrease in the percentage inhibition was observed. The IC50 (50 % of inhibition) value of the extract was 66.50 ± 1.90 µg/ml. In comparison, Pandey and Ghosh (2022a) demonstrated an IC50 value of 42.54 ± 1.25 µg/ml for the same species of *Astraeus*.

Incidences of multidrug-resistant organisms are currently on the rise, posing challenges to the treatment of a growing array of infectious diseases. Consequently, there exists a pressing necessity for the innovation of novel and efficacious medications targeting present antibiotic-resistant pathogens. Fungal species have demonstrated remarkable potential as sources of bioactive compounds with considerable therapeutic benefits and represent the most abundant reservoirs of secondary metabolites (Biswas *et al.* 2017). The gastroid mushroom discussed in this study exhibited notable antimicrobial properties against the organisms under examination.

The utilization of methanolic extracts from *Astraeus asiaticus* has yielded noteworthy antifungal efficacy against plant pathogenic fungi viz., *Penicillium expansum* PP758388, *Alternaria alternate* PP789274, and *Aspergillus tamari* PP506143. The results of present study indicated that the fungicidal activities of the extract increase due to high amount of secondary bioactive metabolites present in this mushroom species. In the present study, the MIC against *Aspergillus tamari* PP506143 was found to be 0.83 mg /ml, which is highly susceptible as compared to other targeted organisms tested. *Penicillium expansum* PP758388 and *Alternaria alternate* PP789274 showed MIC at 1.33 mg/ml in methanolic extract but with fluconazole, the MIC range varied as 0.42 and 0.33 mg/ml against the pathogenic fungi *Penicillium expansum* PP758388 and *Alternaria alternate* PP789274, respectively. Previous studies have also indicated that variations in antimicrobial efficacy could stem from various factors, such as the genetic compositions of the organisms under examination, the types of solvents utilized during the extraction process of bioactive compounds, and the disparities in the physical and biochemical properties of the antimicrobial elements within the extracts (Bala *et al.,* 2011). To summarize, the methanolic extracts derived from *Astraeus asiaticus* have exhibited substantial antimicrobial effects against the organisms subjected to testing. Additional research is required to assess and validate the antimicrobial properties of these extracts against a broader spectrum of pathogenic microorganisms affecting humans and plants.

CONCLUSION

The study on *A. asiaticus*, an edible mushroom species, was carried out to quantitatively assess various nutritional components, bioactive metabolites, and bioprospection potential. The nutritional and metabolite content revealed that *A.*

asiaticus is rich in protein, carbohydrate, total phenolic content, total flavonoid content, ascorbic acid, crude fibre, and ash content and possesses antioxidant activity, which can be utilized to reduce the nutritional gap caused by the scarcity of food resources for ever-increasing population. The gastroid mushroom investigated offers enough bioprospection potential to serve the heath issue facing the mankind. The nutritional and metabolite content of the mushroom species fall within intended limits, making it safe for human consumption. Since the human body is unable to produce these metabolites, mushrooms such as *A. asiaticus* being a rich source of these bioactive metabolites, needs to be made part of the routine human diet.

ACKNOWLEDGMENTS

The authors are grateful to the Department of Botany, Guru Ghasidas Vishwavidyala, Bilaspur, India for providing a platform to conduct all experiments smoothly. Additionally, we thank UGC New Delhi, for financial support. Lastly, we acknowledge the academic community and colleagues for their insightful discussions, constructive feedback, and inspiration that enriched the quality of this research work.

CONFLICT OF INTEREST

There is no conflict of interest.

REFERENCES

Akata, I., Ergonul, B., Kalyoncu, F. 2012. Chemical compositions and antioxidant activities of sixteen wild edible mushroom species grown in Anatolia. *International Journal of Pharmaceutics*, **8**:134-138; doi: 10.3923/ ijp.2012.134.138.

Altaf, U., Lalotra, P., Sharma, Y.P. 2020. Nutritional and mineral composition of four wild edible mushrooms from Jammu and Kashmir, India. *Indian Phytopatholgy*, **73**:313-320; doi: 10.1007/s42360-020-00230-1.

Ayimbila, F. and Keawsompong, S. 2023. Nutritional Quality and Biological Application of Mushroom Protein as a Novel Protein Alternative. *Current nutrition reports*, **12(2)**:90-307; doi: 10.1007/s13668-023-00 468-x.

Bach, F., Zielinski, A.A.F., Helm, C.V., *et al.*, 2019. Bio compounds of edible mushrooms: In vitro antioxidant and antimicrobial activities. *Lwt - Food Science and Technology*, **107**:214-220; doi: 10.1016/j.lwt.2019.03.017.

Bala, N., Aitken, E.A., Fechner, N., *et al.*, 2011. Evaluation of antibacterial activity of Australian basidiomycetous macrofungi using a high-throughput 96-well plate assay. *Pharmaceutical biology*, **49(5)**:492-500; doi: 10.3109/13880209.2010.526616.

Barber, T.M., Kabisch, S., Pfeiffer, A.F., *et al.*, 2020. The health benefits of dietary fibre. *Nutrients*, ***12*(10)**:3209; doi: 10.3390 /nu12103209.

Barros, L., Cruz, T., Baptista, P., *et al.*, 2008. Wild and commercial mushrooms as a source of nutrients and nutraceuticals. *Food and Chemical Toxicology*, **46**:2742-2747; doi: 10.1016/j.fct.2008.04.030.

Biswas, G., Nandi, S., Kuila, D., *et al.*, 2017. A comprehensive review on food and medicinal prospects of *Astraeus hygrometricus*. *Pharmacognosy Journal*, **9(6)**:799-806; doi: 10.5530/pj.2017.6.125.

Boa, E. 2004. *Wild edible fungi: A global overview of their use and importance to people*. Non-Wood Forest Products Series No. 17, Food & Agriculture Organization, Rome.

Boonsong, S., Klaypradit, W., Wilaipun, P. 2016. Antioxidant activities of extracts from five edible mushrooms using different extractants. *Agriculture and Natural Resources*, **50(2)**:89-97; doi: 10.1016/j.anres.2015.07.002.

Buruleanu, L.C., Radulescu, C., Georgescu, A.A., *et al.*, 2018. Statistical characterization of the phytochemical characteristics of edible mushroom extracts. *Analytical Letters* **51(7):**1039-1059; doi: 10.1080/00032719.2 017.1366499.

Cheung, L.M., Cheung, P.C., Ooi, V.E. 2003. Antioxidant activity and total phenolics of edible mushroom extracts. *Food chemistry*, **81(2)**:249-255; doi: 10.1016/S0308-8146(02) 00419-3.

Dimopoulou, M., Kolonas, A., Mourtakos, S., *et al*., 2022. Nutritional composition and biological properties of sixteen edible mushroom species. *Applied Sciences*, **12(16):**8074; doi: 10.3390/app12168074.

Fothergill, A.W. 2011. Antifungal susceptibility testing: clinical laboratory and standards

institute (CLSI) methods. In: Interactions of yeasts, moulds, and antifungal agents: How to detect resistance (Ed.: Hall, G.S.). Humana Press, Totowa, NJ, pp.65-74.

Hyde, K.D., Bahkali, A.H., Moslem, M.A. 2010. Fungi-an unusual source for cosmetics. *Fungal diversity*, **43**:1-9; doi: 10.1007/s13225 -010-0043-3.

Jagota, S.K. and Dani, H.M. 1982. A new colorimetric technique for the estimation of vitamin C using Folin phenol reagent. *Analytical biochemistry*, **127(1)**:178-182. Doi: 10.1016/0003-2697(82)90162-2.

Joslyn, M.A. 1970. *Methods in food analysis. Physical, chemical and instrumental methods of analysis.* Second edition. Academic Press Inc., New York, USA, xix+845 p.

Martínez-Escobedo, N.A., Vázquez-González, F.J., Valero-Galván, J., *et al.*, 2021. Antimicrobial activity, phenolic compounds content, and antioxidant capacity of four edible macromycete fungi from Chihuahua, Mexico. *TIP Revista Especializada en Ciencias Químico-Biológicas*, **24**:1-11, doi: 10.22201/f esz.23958723e.2021.318.

McDonald, S., Prenzler, P.D., Autolovich, M., *et al*., 2001. Phenolic Content and Antioxidant Activity of Olive Extracts. *Food Chemistry*, **73**:73-84; doi: 10.1016/S0308-8146(00)00 288-0.

Meda, A., Lamien, C.E., Romito, M., *et al.*, 2005. Determination of the total phenolic, flavonoid and proline contents in Burkina Fasan honey, as well as their radical scavenging activity. *Food Chemistry*, **91(3)**:571-577; doi: 10.10 16/j.foodchem.2004.10.006.

On-nom, N., Suttisansanee, U., Chathiran, W., *et al.*, 2023. Nutritional Security: Carbohydrate Profile and Folk Remedies of Rare Edible Mushrooms to Diversify Food and Diet: ThailandCaseStudy. *Sustainability*, **15(18)**:14 034; doi: 10.3390/s151814034.

Ozen, T., Kizil, D., Yenigun, S., *et al*., 2019. Evaluation of bioactivities, phenolic and metal content of ten wild edible mushrooms from western Black Sea region of Turkey. International *Journal of Medicinal Mushrooms*, **21(10)**; doi: 10.1615/Int.J.Med. Mushrooms.2019031927.

Pandey, K. and Ghosh, S.K. 2022a. Biodiversity of *Astraeus asiaticus*, a wild indigenous mushroom, in the forests of Bankura district, West Bengal and its antioxidant property. *Acta Mycologica*, **57**:1-19; doi: 10.5586/am. 575.

Pandey, K. and Ghosh, S.K. 2022b. Nutritional profile and mycochemistry analysis of some mushrooms in West Bengal. *Plant Cell Biotechnology and Molecular Biology*, ***23*(13-14)**:88-99; doi: 10.56557/pcbmb/2022/v2 3i13 -147611.

Pavithra, M., Sridhar, K.R., Greeshma, A.A. 2018. Nutritional quality attributes of edible gasteroid wild mushroom *Astraeus hygrometricus*. In: Fungi and their role in sustainable development: current perspectives. (Eds.: Gehlot, P. and Singh, J.) Springer Nature, Singapore, pp.367-382.

Phosri, C., Watling, R., Martín, M.P., *et al.*, 2004. The genus *Astraeus* in Thailand. *Mycotaxon*, ***89*(2)**:453-464.

Plummer, D.T. 1990. Estimation of carbohydrates by the anthrone method. An Introduction to Practical Biochemistry, **179**:2-3.

Sanmee, R., Dell, B., Lumyong, P., *et al*., 2003. Nutritive value of popular wild edible mushrooms from northern Thailand. *Food Chemistry*, **82(4)**:527-532; doi: 10.1016/S03 08-8146(02)00595-2.

Singh, N. 2011. Wild edible plants: a potential source of nutraceuticals. *International Journal of Pharmaceutical Sciences and Research*, **2(12)**:216-225.

Sudheep, N.M. and Sridhar, K.R. 2014. Nutritional composition of two wild mushrooms consumed by the tribals of the Western Ghats of India. *Mycology*, **5(2)**:64-72; doi: 10.1080/ 21501203.2014.917733.

Zeller, S.M. 1949. Keys to the Orders, Families, and Genera of the Gasteromycetes. *Mycologia*, **41(1)**:36-58; doi: 10.1080/00275514.1949.12 017751.

Zhou, S., Ma, F., Zhang, X., *et al.*, 2016. Carbohydrate changes during growth and fruiting in *Pleurotus ostreatus*. *Fungal Biology*, **120(6-7)**:852-861; doi: 10.1016 /j.funbio.2016.03.007.