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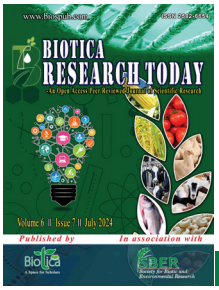

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Rugda Mushroom: Exploring Nutri-Medicinal and Culinary Importance and Challenges in Commercial Cultivation

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Abstract

Mushrooms, prized for culinary and medicinal uses, include diverse macrofungi like *Astraeus* spp, known locally in Jharkhand as Rugda or Futka. Collected from sal forests during the monsoon in the Chota Nagpur Plateau (Jharkhand, West Bengal, Bihar, Odisha), Rugda mushrooms come in two types: Chandana and Sabaiya. They boast high protein content and therapeutic properties, including antioxidative, antimicrobial and anticancer effects. Despite these benefits, Rugda mushrooms are understudied, highly perishable and difficult to cultivate artificially, limiting their year-round availability and transport. Economically important to local tribal communities, they remain unprocessed in the market. This article highlights the need for research into Rugda mushrooms' cultivation, shelf-life enhancement and potential use in nutraceuticals, addressing their morphology, distribution, nutritive and medicinal properties and commercialization challenges.

Keywords: Phylum Basidiomycota, Rugda Mushroom, Sal Forest, Vegetarian mutton

Introduction

Mushrooms are a valuable food source and traditional medicine known for their health-promoting properties. These macro fungi belong to the phylum Basidiomycota and feature large fruiting bodies that are prized for their appealing flavors, tastes and textures, making them edible. There are over 2,000 edible fungi species, with around 200 being commercially or artificially cultivated. Of these, 20 species are grown on an industrial scale, including *Agaricus bisporus*, *Lentinus edodes* (shiitake), *Pleurotus* spp. (oyster mushrooms), *Volvariella volvacea (*Paddy straw mushroom*) Auricularia auricula*, *Flammulina velutipes* and others (Wei *et al.*, 2022).

In addition to commercially cultivated mushrooms, a multitude of wild mushrooms, primarily from the genera *Astraeus*, *Amanita*, *Russula* and *Termitomyces* hold medicinal value and are used for culinary purposes. These mushrooms are essential for food security among ethnic and tribal populations. Many of these wild mushrooms form symbiotic associations with trees, supporting the growth of both indigenous and commercial plantations in tropical forests.

Astraeus spp., also known as false earthstars or puffballs, are non-culturable wild edible mushrooms found in temperate and tropical ecosystems. With about 10 species worldwide, including *A. hygrometricus*, *A. asiaticus* and *A. odoratus*, they are popular among tribal communities for their therapeutic value. In Jharkhand, they are known as Rugda, Puttu or Futka and in Odisha, they are called Mati Tara (Earth Star). These mushrooms are typically collected during the monsoon season, in June and July, from nearby Sal forests. Despite their edibility and therapeutic potential, Rugda mushrooms have been understudied. This article aims to examine their morphology, distribution, uses and commercialization challenges through field and literature surveys.

Morphology and Distribution of the Mushroom

Rugda mushrooms typically grow in the naturally decomposed leaf litter of Sal trees (*Shorea robusta*) or form ectomycorrhizal associations with plants and are primarily available during the monsoon season. In India, it is widely distributed across the northern regions (Uttarakhand, Punjab and Himachal Pradesh), southern regions (Karnataka and Kerala) and eastern regions (Jharkhand, Odisha and West Bengal) (Figure 1). The Chota Nagpur Plateau,

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encompassing states such as West Bengal, Odisha, Bihar and especially Jharkhand, is a hub for the abundant availability and consumption of wild Rugda mushrooms. This abundance significantly enhances the socio-economic status of the rural tribal communities in these regions.

In Jharkhand, two types of Rugda mushrooms (*Astraeus* spp.)

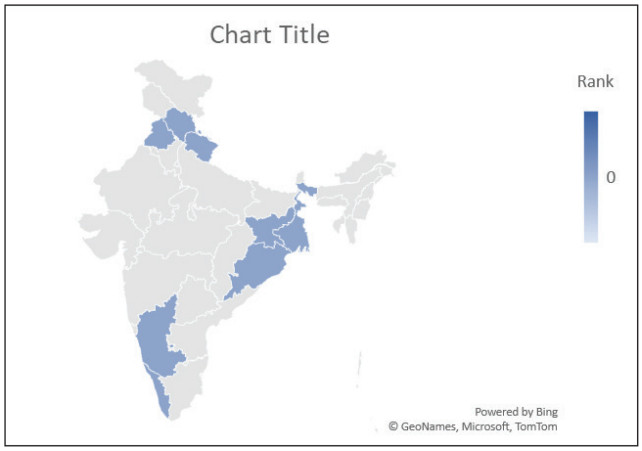

Figure 1: Coloured regions of the India map indicating the geographical distribution of Rugda mushrooms

are found locally: *Chandana* and *Sabaiya*. The first one has a brownish outer coat and is available early in the season and the second one has a whitish outer covering. Based on molecular analysis, these mushrooms are classified as *A. asiaticus* and *A. odoratus*. Additionally, *A. hygrometricus* has been identified in some parts of West Bengal (Topno and Shrivastava, 2021). Morphologically, the basidiomata of the Rugda mushroom are near spherical to oval-shaped. The colour of the basidiomata changes from ashy-white or pale-white in the early stage to brown in the mature stage. It is available in varying sizes ranging from (1 cm to 4 cm and the average size is 2.4 cm diameter) and the outer surface is covered with thin hairy masses. The inner surface of the basidiomata is filled with spongy-like spore masses and the colour of the inner structure changes from yellowish-white in the early stage to blush-white in the mid-stage. Finally, it turns to brownish-black at the mature stage (Figure 2). The robustness of the external layer of the mushroom escalates with an increase in the age of the mushroom.

Nutritive Value

In several Asian nations, a variety of wild mushrooms are widely favoured as a culinary delicacy by indigenous groups rather than cultivated fungi. Nevertheless, the accurate assessment of the nutritional content of mushrooms that grow in the wild has been constrained by the fragmented understanding of their makeup and the insufficient documentation regarding the presence of their components. The detailed nutritional profiling of the Rugda mushroom (*A. hygrometricus*) is reviewed by Biswas *et al.* (2017). According to the report, the moisture content, carbohydrate, fibre, total amino acid, macro and micro-nutrients and especially protein content of the mushroom are estimated and which is listed in table 1. This indicates that it is high in protein and has less carbohydrate.

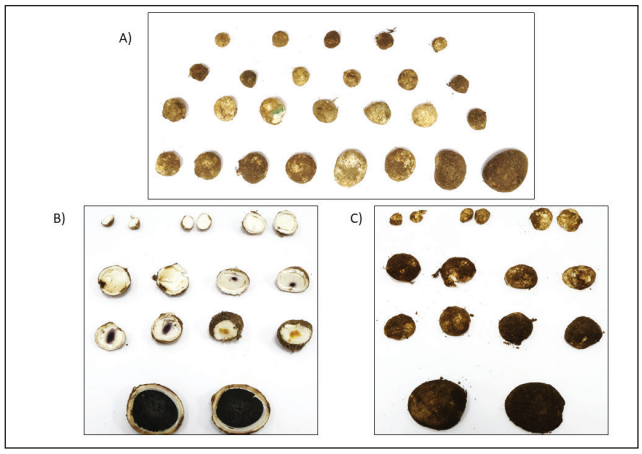

Figure 2: Morphology of basidiocarp of Rugda Mushroom collected from the local market in Ranchi, Jharkhand [A) Size Variation in Rugda mushroom, B) Development of whitish inner spore masses to Black mature spore masses, C) Change of colour of the outer surface from whitish-yellow at an early stage to brownish-black outer surface at the mature stage of basidiocarp of the mushroom]

Medicinal Properties

Thanks to their diverse range of biologically active compounds, mushrooms are renowned for their therapeutic benefits. At present, there is a considerable focus on the secondary metabolites or bioactive compounds derived from mushrooms due to their promising potential in the exploration of novel pharmaceuticals or lead compounds. Mushrooms, particularly Rugda mushrooms (*Astraeus hygrometricus*), are known for their therapeutic properties, including antioxidative, antimicrobial, anti-inflammatory, immunomodulatory, antiparasitic, anticancer, antidiabetic and protective effects on organs like the kidney and heart (Biswas *et al.*, 2017). The ethanolic extract of *A. hygrometricus* is rich in phenolic and flavonoid compounds, with strong nitric oxide synthase activation properties. These compounds are crucial in combating various life-threatening diseases, including chronic hepatotoxicity, acute and chronic inflammation, progression of coronary artery disease and cancer by disrupting the cell cycle and show inhibitory effects on various cancers, including Ehrlich's ascites carcinoma. *A. hygrometricus* extracts also exhibit antifungal and antibacterial properties and are being explored as a cost-effective alternative for treating *Leishmania donovani*, a parasite. Diabetes mellitus, a severe metabolic disease affecting over 180 million people globally, benefits from mushroom extracts like those of *A. hygrometricus*, renowned for their elevated levels of dietary fiber and minimal fat composition. A study demonstrated that an ethanolic extract from *A. hygrometricus* reduced blood glucose levels in diabetic mice, improving glucose tolerance. Mushrooms with higher mannitol content are particularly beneficial for diabetic patients. Water-soluble Fraction I, derived from the fruit bodies of *A. hygrometricus*, acts as an immunomodulator by stimulating immune responses.

Culinary Properties

Wild edible mushrooms hold significant spiritual and

Table 1: Nutrient status of the Rugda Mushroom (*A. hygrometricus*) [Biswas *et al*., 2021]

Sl. No.	Parameter Analysed	Quantity
1.	Moisture	83.9%
2.	Carbohydrate	64.3 + 3.23 g/ 100 g (dry weight basis)
3.	Free amino acid	6.5 + 0.90 g/ 100 g (dry weight basis)
4.	Fat	3.2 + 0.85 g/ 100 g dry weight
5.	Fibre	10.8 + 1.02 g/ 100 g dry weight
6.	Protein	16.5 + 1.35 g/ 100 g dry weight
Macro-Nutrients		
7.	Phosphorus (P)	5.7 mg g^{-1} dry weight (young) - 2.2 mg g^{-1} dry weight (mature)
8.	Potassium (K)	26.1 mg g^{-1} dry weight (young) - 12.8 mg g^{-1} dry weight (mature)
9.	Calcium (Ca)	0.8 mg g^{-1} dry weight (young) - 2.4 mg g^{-1} dry weight (mature)
10.	Magnesium (Mg)	1.2 mg g^{-1} dry weight (young) - 1.6 mg g^{-1} dry weight (mature)
11.	Sulphur	5 mg g^{-1} dry weight (young) - 1.7 mg g^{-1} dry weight (mature)
Micro-Nutrient		
12.	Iron (Fe)	2059 mg kg^{-1} dry weight (young) - 3254 mg kg^{-1} dry weight (mature)
13.	Zinc (Zn)	105 mg kg^{-1} dry weight (young) - 203 mg kg^{-1} dry weight (mature)
14.	Manganese (Mn)	81.7 mg kg^{-1} dry weight (young) - 329 mg kg^{-1} dry weight (mature)
15.	Copper (Cu)	25.2 mg kg^{-1} dry weight (young) - 16.5 mg kg^{-1} dry weight (mature)
16.	Boron (B)	2.4 mg kg^{-1} dry weight (young) - 2.4 mg kg^{-1} dry weight (mature)

socio-economic importance for tribal communities, with the knowledge of their uses being passed down through generations. Rugda mushrooms, known as the "vegetarian mutton of Jharkhand," are crucial for tribal communities in Jharkhand for food security and traditional therapeutic practices. These unique, highly palatable mushrooms are rich in protein, minerals, vitamins and are free of carbohydrates. After collection from local market, these mushrooms are washed and cooked as a vegetable. The tribal people of Jharkhand believe that Rugda mushrooms possess significant medicinal properties, which are gradually reduced by boiling or cooking. Consequently, they consume the immature, small Rugda mushrooms raw to preserve their purported health benefits.

Availability and Challenges in Cultivation

The Rugda mushroom, found near Sal trees, thrives during the monsoon period and particularly in sandy soils. It is highly perishable, lasting only one day and cannot be grown in other seasons, complicating its availability throughout the year and making long-distance transport difficult. Its growth is restricted to specific climatic conditions and seasons and attempts at artificial cultivation have been unsuccessful. Unlike button mushrooms, paddy straw mushrooms and milk mushrooms, Rugda mushrooms fail to grow under artificial conditions.

Commercial Prospects

Rugda mushrooms naturally grow under Sal trees during the monsoon. Local tribal people collect these mushrooms and sell them in nearby markets, which helps reduce poverty and strengthens their livelihoods by providing a reliable source of income (Figure 3). Rugda mushrooms are highly valued in different regions and can fetch high prices in the market, ranging from 200 to 2000 rupees kg^{-1}. To date, it is only available in its unprocessed form as a fresh vegetable. Unlike other commercial mushrooms, which are available in various processed or value-added forms, Rugda mushrooms are not available. This may be due to their high demand for fresh form, high perishability, or the lack of established processing practices, as they have not yet gained national significance for consumption. Another drawback to its commercialization is the inability to cultivate it artificially, preventing its availability throughout the year.

Figure 3: A Tribal person selling Rugda mushroom in local market after it was collected during rainy season

Conclusion

Exploring *Astraeus* spp. offers numerous benefits, with some species being edible, many having medicinal properties and almost all forming ectomycorrhizal associations with various forest tree species. Limited research on the nutritional and medicinal properties of Rugda mushrooms suggests their potential to prevent various human ailments. More studies are needed to fully understand their biological activities and potential for domestication, processing and nutraceutical preparations, as only a few bioactive compounds have been identified so far. Research into artificial cultivation and methods to enhance the shelf-life of Rugda mushrooms is essential for their commercialization. These advancements will make the mushrooms available throughout the year and across the country.

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