Research Journal of Agricultural Sciences
Volume 17; Issue 04 (July–Aug 2026); pp 521–524

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Calocybe indica Cultivation: A Comprehensive Review of Substrate and Nutritional Potential

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Received: 23 June 2026; Revised accepted: 12 Aug 2026

Abstract

Milky mushroom (*Calocybe indica*) is an important tropical edible mushroom recognized for its nutritional value, texture, prolonged shelf life and suitability for cultivation under warm environmental conditions. Unlike many temperate mushrooms *Calocybe indica* can be cultivated effectively at relatively higher temperatures making it particularly promising for tropical and subtropical regions. Its productivity is strongly influenced by the composition and quality of the spawn quality, substrate, supplementation, moisture content, temperature, RH humidity and management of fruiting conditions. Crop residues like wheat, paddy, maize, sugarcane straw and other lignocellulosic materials can serve as potential substrates for its cultivation, providing an opportunity for converting agro-wastes into valuable food products. This study summarizes the major aspects of milky mushroom cultivation with particular emphasis on substrate selection and preparation, spawning, environmental requirements, fruiting, biological efficiency, yield optimization, nutritional composition, cultivation constraints and prospects for commercial production of milky mushrooms. The review also highlights the importance of sustainable substrate utilization and improved cultivation practices for enhancing productivity while reducing agricultural waste. Further research on strain improvement, substrate optimization, supplementation, environmental control, post-harvest technology, and value-added products may contribute to the wider commercialization of *Calocybe indica*.

Key words: *Calocybe indica*, Milky mushroom, Mushroom cultivation, lignocellulosic substrate, Spawn, Biological efficiency, Yield, Nutritional composition, Sustainable agriculture

Calocybe indica, commonly referred to as the milky mushroom *Dudh chatta* or summer mushroom, is a large and tasty variety discovered in India by Purkayastha and Chandra in 1976, This appealing fungus features sizable, milky white sporophores and is classified within the *Tricholomataceae* family of the Agaricales order. It naturally grows in humus-rich soil beneath roadside trees in forested areas [1]. The ideal temperature range for growing this mushroom is between 30 and 35 °C, according to certain workers, fruit body initiation was more successful at 30 °C and 90% relative humidity, while spawn run was best at 32 °C [2]. There have been reports of yield decline at temperatures below 25 °C [3]. Fruit body formation was less favoured by total darkness, whereas stipe elongation was aided by diffused light, When the fungus was incubated at 600–800 lux light intensity, it showed strong and vigorous mycelial growth [4]. When the cased beds were incubated at 1600 lux of light, the highest yield was achieved, Stipe length significantly decreased at increasing light levels, whereas pileus breadth significantly increased [5]. Four distinct agro-residues paddy straw, coirpith, wood shaving, and banana waste were used to grow milky mushrooms. The maximum energy value of 466 was found when the substrates' energy value was calculated based on their cellulose, hemicellulose, and lignin composition. K Cal per 100 gm substrate in coirpith, followed by wood shavings (380 K Cal per 10 gm), banana trash (435 K Cal per 100 gm), and paddy straw (391 K Cal per 100 gm) [1].

Importance of substrate

The cultivation substrate is the principal nutritional and physical support for mushroom growth. Its chemical composition, particle size, moisture-holding capacity, aeration and nutrient availability can influence mycelial colonization and fruiting [6]. Agricultural residues are particularly suitable because they contain cellulose, hemicellulose and lignin that can be partially degraded and utilized by fungi, Paddy straw and wheat straw are among the commonly investigated substrates for *C. indica* cultivation [7]. Studies comparing different substrates and casing materials have demonstrated that both substrate and casing characteristics can influence mycelial growth, primordia initiation, fruiting-body characteristics and biological efficiency [8].

Paddy straw and wheat straw

Paddy straw is an attractive substrate because of its wide availability in rice-producing regions. Wheat straw is also widely investigated and provides a suitable lignocellulosic base for cultivation [9]. The use of these residues has an additional environmental advantage because mushroom cultivation provides a route for converting otherwise low-value biomass

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Citation: Jain A, Soni U, Dehariya P. 2026. *Calocybe indica* cultivation: A comprehensive review of substrate and nutritional potential. *Res. Jr. Agril. Sci*. 17(4): 521-524.

into edible food [10]. It can be cultivated on wheat / paddy straw at temperature around 25-35° C and 70 to 90% relative humidity, at this condition 70-85 kg fresh mushroom per 100 kg substrate can be obtained within 12-16 week production cycle [9]. The best casing material and the rice straw was the best substrate for the commercial cultivation of *C. indica*. According to [11] the biological efficacy could be improved when cotton waste and sunflower stalks substrate were used in various concentrations with paddy straw (3:1, 1:1 and 1:3 v/v) for sporophore production.

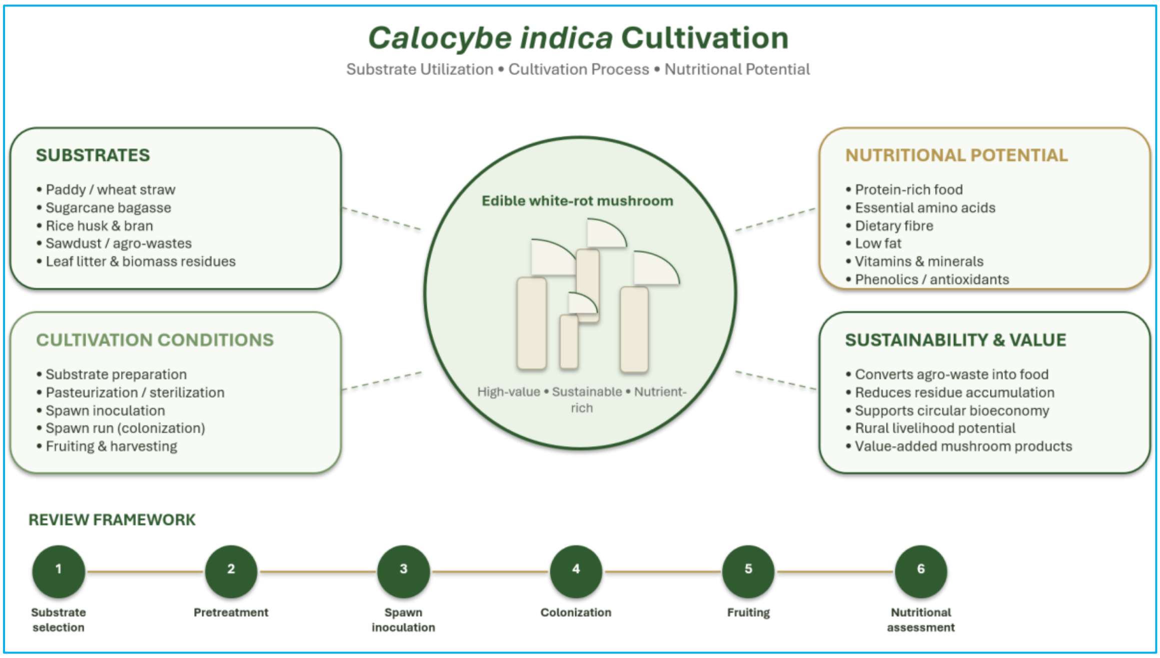

Fig 1 Overview of *C. indica* cultivation, substrate utilization, cultivation process, and nutritional potential

Moisture and treatment

Adequate moisture is essential for substrate colonization, while excessive moisture can reduce aeration and encourage contamination, Therefore, moisture management must provide a balance between water availability and oxygen diffusion [12]. Before spawning, the substrate is generally subjected to an appropriate treatment to reduce competing microorganisms, depending on the cultivation system, pasteurization or sterilization may be used. After soaking in water for eighteen to twenty-four hours, the substrates were drained of any extra water, when steam sterilization is used, this time can be shortened, Saturating the substrate with water is the primary goal of soaking. Filling a gunny sack with straw and dipping it in water makes soaking simpler [13].

Cultivation process

One of the best edible mushrooms that can be grown all year round in India's tropical climate is the milky mushroom, Additionally, its extended shelf life, low capital investment, and easy cultivation method make it a preferable option for both mushroom growers and customers, Milky white mushroom farming is a labor-intensive and energy-intensive cultivation process involving the following six steps: spawn production, substrate pre-treatment, mushroom bed preparation, cropping room maintenance during spawn run, mushroom production, packing and spent mushroom substrate management [14].

Spawning

Healthy and vigorous spawn is essential for rapid and uniform colonization; Poor-quality or contaminated spawn can delay colonization and increase production losses [15]. Following spawning, the substrate is maintained under conditions favorable for vegetative mycelial development. Complete colonization provides a strong foundation for subsequent fruiting. The rate of spawning is 4% of the wet weight of straw that has 60–65% moisture [16]. After the spawn has completed its run, the casing is an important stage in its development. The quantity and quality of the easing substance employed impact both the pinhead initiation and the final yield [14]. Furthermore, under controlled settings, they are less likely to become contaminated or discoloured and these species are inexpensive to produce, indicating that industrial production may require a brief crop cycle of roughly seven to eight weeks [14].

Casing

Casing is an important stage in *C. indica* production. The casing layer acts as a moisture reservoir and provides a suitable microenvironment for fruiting initiation. The casing layer is essential for starting fructification during the change from the vegetative to the reproductive phase [17]. Casing materials, such as peat moss, loam soil, wasted mushroom substrate, coconut coir, biogas slurry, farmyard manure, and so on, must have a high water-holding capacity, physical support, wetness, and a good air space ratio to offer a gaseous exchange, porosity, and bulk density [18]. The casing material was made with the proper amounts of sand (25%), garden loam soil (50%), and farmyard manure (25%). Fruiting bodies in the shape of needles begin to appear in 3–5 days and mature in about a week when the light is accessible for a significant period of time [18]. Seven to eight centimeter-diameter mushrooms are gathered, twisted, cleaned, and packaged in perforated polyethylene or polypropylene bags for sale [18]. Mushrooms can be wrapped in cling film for extended storage. Several researchers discovered that casing was a necessary condition for *C. indica* to properly fructify [18]. On milky white mushroom beds, [19] employed loamy soil or garden soil and sand (1:1) thoroughly mixed with calcium carbonate at a 12% level (pH 7). According to [20], compared to alternative media including peat soil, sand, biogas slurry, farm yard manure, and coir pith compost, partially steamed clay loam soil (pH 8.4) produces maximum yields and a higher number of buttons.

Nutritional potential of C. indica

The nutritional composition of *C. indica* is an important component of its commercial value. Mushrooms generally provide protein, carbohydrates, dietary fiber, minerals and vitamins while containing relatively low levels of fat [21]. Published analyses of cultivated *C. indica* have reported the presence of important nutrients and mineral elements, Comparative analysis has identified potassium, sodium and phosphorus among the mineral elements detected in the mushroom, while vitamins such as riboflavin and niacin have also been reported [19]. The nutritional composition can vary according to strain, cultivation substrate, maturity and analytical methodology. Therefore, nutritional values should not be considered fixed characteristics of the species [22]. *C. indica* has been shown to be an excellent source of vitamins, minerals, proteins, and amino acids; also, because of their low-fat content, they are a great choice for heart patients. They are also a good source of polyphenols (flavonoids, alkaloids, and triterpenoids) and bioactive polysaccharides like β-glucans [22-23]. Thus, scavenging mechanisms, increased antioxidant activity, anti-diabetic, anti-cancer, and anti-lipid peroxidation properties may be caused by these active molecules. Probiotic qualities of *Calocybe indica* polysaccharides include pleuran, lentinan, schizophyllan, β-glucans, mannans, chitin, hemicellulose, galactans, and xylans [14].

Vitamins

Among the four vitamins studied, *Calocybe indica* was found to be a potent source of vitamin B, followed by vitamins E, A, and C, since vitamins are essential to human nutrition and there are few conventional sources of vitamins, *Calocybe indica* may be a good substitute for the vitamin diet particularly in nutritionally deficient populations and communities [24].

Carbohydrates

The polysaccharides found in mushrooms, such as the calocyban from *Calocybe indica*, have been developed and used as functional food ingredients. These polysaccharides have been shown to be exceptional representatives of D-glucans with common (1→3) or (1→6) β-linked glucose backbones and are differentiated by varying patterns and degrees of branches [25].

Fatty acids

Stearic acid, lignoceric acid, myristic acid, lauric acid, palmitic acid, heneicosylic acid, pentadecyclic acid, margaric acid, and arachidic acid were saturated fatty acids, while linoleic acid, elaidic acid, myristoleic acid, eicosapentaenoic acid, erucic acid, palmitoleic acid, gondoic acid, and dichomo-linolenic acid were unsaturated fatty acids in a study by [21]. The most prevalent fatty acids in *Calocybe indica* were linoleic acid and elaidic acid [21].

Table 1 Mineral composition of *Calocybe indica* per 100 g [19], [26-27]

Mineral	Unit	Fresh / Wet	Dry
Calcium (Ca)	g	0.01	0.21
Copper (Cu)	mg	0.9	Not detected
Iron (Fe)	mg	1.8	56.25
Zinc (Zn)	mg	8.0	12.87
Magnesium (Mg)	g	0.51	0.13
Manganese (Mn)	mg	0.53	1.64
Selenium (Se)	µg	Not detected	13.20
Cadmium (Cd)	µg	Not detected	Not detected
Lead (Pb)	µg	Not detected	Not detected
Phosphorus (P)	g	0.62	Not detected
Sodium (Na)	g	0.37	Not detected
Potassium (K)	g	1.97	Not detected

CONCLUSION

In terms of protein, carbohydrates, fiber, amino acids, energy levels, and a good variety of vitamins and minerals, it can be said that the studied edible fungus, *Calocybe indica*, is a good food source. These mushrooms' nutritional qualities may offer substantial protection against diseases caused by malnutrition. Furthermore, regular use of *C. indica* mushrooms can be crucial in promoting health and preventing disease, given the existing nutrient deficiencies and health issues that exist worldwide. The milky white mushroom could be crucial in meeting the expanding market demand for edible mushrooms due to its unmatched productivity and shelf life compared to other cultivated mushrooms worldwide.

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