

Production Of Edible Mushrooms to Meet the Food Security: A Review

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Abstract

Mushrooms as part of food have been consumed since ancient times from Greek to Rome to China as a booster to strengthen the immunity of war army men. Gradually it become part of cultured food in some regions. Later when extensive studies were performed on the nutritional value of mushrooms their cultivation and consumption increased tremendously. Mushroom cultivation has grown rapidly over the year due to its low-calorie load, fat, carbohydrates and negligible amount of cholesterol, also mushrooms add important nutrients such as potassium, selenium, vit-B2, vitB3, vit-D, proteins and an ample amount of fiber in our food. The high demand, market and nutritional value, low cost of production, as well as the medicinal properties of mushrooms, draw attention to their mass production. India is an agricultural country with a wide range of agroclimatic conditions. It generally produces 604 million tons of agricultural waste annually. Mushroom not only recycle the agricultural waste but also fills the nutritional gap of this large population. There is a 4.3% annual increase in mushroom cultivation every year. The total production is maximum in the white button mushroom with the share of 74% of all the mushroom production. Recently many peoples are adapting to mushroom cultivation to make their lives better as well bridging the gap in the nutrition of the society. Now it is high time that the Indian population needs to understand its right nutritional and medicinal value of cultivated and wild varieties of mushrooms. This review primarily focuses on the nutritional and medicinal value of different mushrooms, growth conditions, and their future prospects with indications for certain production issues.

Keywords- mushroom, immunity, nutrition, medicinal, and agricultural waste

Introduction

Mushroom is a plump spore-bearing fruiting body of the fungus belong to basidiomycetes. The most commonly cultivated mushroom is (*Agaricus bisporus*, followed by *Lentinus edodes*, *Pleurotus spp.*, and *Flammulina velutipes*). Thomas did the first mushroom cultivation in India in the year 1943 in agricultural college and cultivated the paddy straw mushroom which led to enhancing the cultivation technique in India. In the current scenario mushroom farming is the most

profitable agribusiness in India and it can be started with the minimum investment and space, therefore the farmers with lower or minimal income can also invest and run their own farm. It has become the alternate source of income for farmers in agriculture. Mushrooms are a rich source of nutrition, high amount of fiber, and contain less fat predominantly of unsaturated fatty acids such as linoleic acid, recently it has come to the focus that mushrooms are a rich source of natural Vit-D etc. Due to its several health benefits like they are low in calories, carbohydrates, and fats it has become a part of

the daily diet all over the world (Sanmee et al., 2003). More than 2000 varieties existed but 25 are accepted as a portion of food and few are commercially accepted. Mushrooms are with a high nutritional and functional value that's why they are considered for their medicinal properties (Chang and Miles, 2005; Beluhan and Ranogajec, 2011) however, there is no clear distinction between the edible and medicinal mushrooms because many of the edible mushrooms have therapeutic properties and several used for medical purpose are also edible. China is the biggest producer of mushroom around the world. Mushrooms are an excellent source of minerals such as phosphorus, magnesium, selenium, copper, and potassium vitamins such as vitamin A and D, and are also rich in dietary fiber and chitin and β -glucans (Samsudin and Abdullah, 2019). Humans for centuries have consumed this not only for nutrition but also for taste and healing properties (Ma et al, 2018). An enormous assortment of mushrooms has been used generally in various societies for the upkeep of wellbeing, just as in the avoidance and treatment of infections through their immunomodulatory and antineoplastic properties. Somewhat recently, the interest in the drug capability of mushrooms has been expanded quickly, and it has been proposed that many mushrooms resemble scaled-down drug plants creating accumulates with marvelous natural properties. Furthermore, the extended information on the atomic premise of tumorigenesis and metastasis has offered the chance for finding new medications against strange subatomic and biochemical signs prompting disease (Zaidman et al., 2005). In excess of 100 therapeutic capacities are created by mushrooms and organisms and the key restorative uses are cell reinforcement, anticancer, antidiabetic, antiallergic, immunomodulating, cardiovascular defender, anticholesterolemic, antiviral, antibacterial, antiparasitic, antifungal, detoxification, and hepatoprotective impacts (Zhang et al., 2011).

Nutritional value

The steep rise in protein-rich food for human consumption makes the way to search for alternative protein sources where traditional

sources are found incompatible to meet the growing demand (Mukherjee and Nandi, 2004). Mushrooms have become a valuable diet for vegetarians because of their nutritional loads as mentioned earlier, who abstain from food since they give everyone the fundamental or essential amino acids to meet the amino acids requirement for adults; additionally, mushrooms have higher protein content than most vegetables. Moreover, palatable mushrooms contain a wide range of bioactive mixtures with various human health benefits (Chakrabarti et al., 2018). The nutritional status and chemical compositions of mushrooms vary among species and on the basematerial/substrate of production, environment of the cultivated farm and post-harvest practices (Mattila et al., 2001; Barros et al., 2007). Cooking practices also significantly change the nutritive composition of mushrooms (Mattila et al., 2001; Barros et al., 2007).

Mineral composition of the common edible Mushrooms

The composition of minerals in the edible Mushrooms typically varies from 60 to 120 g/kg on a dry basis. In wild-growing species, their composition is comparatively higher than the cultivated species. Even so, it appears that dry matter contents are less variable than carbohydrates, lipids, and crude protein. The average values of nitrate, chlorates, and sulfates, in wildy growing species, are 22.6, 20.4, and 3.6 g/kg1 respectively on a dry basis. Phosphates, chlorides, and nitrites were all significantly reduced in concentration, while bromides and fluorides were found to be in negligible (Table-1).

Nutraceuticals

Nevertheless, the healthful parts found in consumable mushrooms, some have been found to involve significant measures of bioactive mixtures. The substance and kind of organically dynamic substances might shift extensively in palatable mushrooms; their centralizations of these substances are influenced by contrasts in strain, substrate, development, formative stage, age, stockpiling conditions, handling, and cooking practices (Mattila et al., 2001). In China,

numerous types of eatable wild-developed mushrooms, such as *Tricholoma matsutake*, *Lactarius hatsudake*, *Boletus aereus*, are valued as food and furthermore in conventional Chinese medication (Hasan and Aunsary, 2020). The rich measure of proteins, starches, fundamental minerals, and low energy levels adds to thinking about some wild-developed mushrooms as great nourishment for the shopper, which can basically measure up to meat, and eggs.

Lipids

Despite mushrooms are not an ideal source of lipids, their lipid contents typically include important fatty acids like oleic, linoleic, and linolenic as the main constituents. Therefore, mushrooms have the benefit of having high quantities of polyunsaturated fatty acids (PUFA) in comparison to other foods of vegetable and animal origin. Linoleic acid content varies from 0.0–81.1 percent, oleic acid around 1.0 and 60.3 percent, and linolenic acid between 0.0–28.8 percent, in total 100 g of fatty acids found in mushrooms. These fatty acids might add to the decrease the blood cholesterol level. It is significant that trans-isomers of unsaturated fatty acids have not been distinguished in mushrooms (Sande, et al 2019).

Phenolic Compounds

Phenolic compounds are auxiliary metabolites having a fragrant ring with at least one hydroxyl group, and their constructions can be a straightforward phenolic particle or a perplexing polymer. They show a wide scope of physiological properties, for example, anti-allergenic, anti-atherogenic, mitigating, antimicrobial, antithrombotic, cardioprotective, and vasodilator impacts. The fundamental attribute of this group of mixtures has been identified with its cell reinforcement action since they go about as decreasing specialists, free extreme foragers, singlet oxygen quenchers, or metal particles (Balasundram et al., 2006).

Proteins

Bioactive proteins are a significant piece of practical parts in mushrooms and furthermore

have an extraordinary incentive for their drug potential. Mushrooms produce countless proteins and peptides with intriguing natural exercises like lectins, fungal immunomodulatory proteins, ribosome inactivating proteins, antimicrobial proteins, ribonucleases, and laccases. Fungal immunomodulatory proteins are another group of bioactive proteins segregated from mushrooms, which have shown a likely application as adjuvants for growth immunotherapy primarily because of their action in stifling cancer intrusion and metastasis (Xu et al., 2011).

Commonly cultivated and edible mushroom White button mushroom

A. bisporus, from the *Agaricus* genera, is the most evolved mushroom all throughout the planet (Chang and Wasser, 2012). *Agaricus* species, the most developed mushroom around the world of eatable mushrooms are these days generally utilized and read for their restorative and helpful properties. A lectin from *A. bisporus* and a protein from *A. polytricha* have been viewed as powerful invulnerable energizers; in this way, these macromolecules might be considered for drug usage and these organisms might be delegated sound food. *A. bisporus* removal has been displayed to forestall cell multiplication in bosom malignant growth (Adams et al., 2008). *A. blazei* is an eatable mushroom local to Brazil and it has been developed particularly in Japan. It is an exceptionally famous basidiomycete known as "sun mushroom," and these days it is devoured around the world as food or in tea because of its therapeutic properties. Its organic product bodies show antimutagenic, anticarcinogenic, and immunostimulatory exercises (Hakime-Silva et al, 2013). This social affair of edible mushrooms is nowadays comprehensively used and read for its helpful and medicinal properties.

Cremini mushroom

These are as same as white button mushroom just a difference in the strains of these mushrooms. It has a bit more flavor than the white button mushroom. Cremini mushrooms are at the center phase of development, more brown than

the natural white mushroom, but not exactly as full grown as the huge portobello. Consequently, you may likewise hear creminis alluded to as "child bellas," or "child portobellos." White mushrooms are the most youthful, least mature assortment. Cremini mushrooms have a hazier shading and a meatier surface and flavor, and can likewise be tracked down entire or cut. Portobello is the most adult, "totally mature," mushroom, maybe. It will in general be a lot bigger and is regularly sold as the cap alone (Sonnenberg et al., 2011). However, crimini mushrooms are a wellspring of limited quantities of nutrients and minerals, their medical advantages will quite often come from different variables. For instance, the enzyme and microscopic organisms contained in crimini mushrooms give a few medical advantages.

Crimini mushrooms Boost Immune System

Eating crimini mushrooms might actually help your insusceptible framework. In the same way as other mushroom types, criminis contain a lot of accommodating microorganisms. A portion of these microorganisms is gainful to the microbiome found in the human intestinal system. These supportive microscopic organisms can further develop absorption and lift the body's invulnerable reaction.

Crimini mushrooms help in preventing cancer

Crimini mushrooms might actually secure against bosom malignant growth and cellular breakdown in the lungs. This impact is an aftereffect of the aromatase inhibitors in crimini mushrooms. Aromatase inhibitors block a protein called aromatase that advances the production of estrogen, a chemical that advances the development of certain sorts of carcinogenic growths (Rogers et al., 2012).

Oyster mushroom

Oyster mushrooms notwithstanding their dietary benefit, they have therapeutic properties and other gainful impacts and wellbeing advancing impacts (Jayakumar et al., 2008). Oyster mushrooms are cosmopolitan and belong to the family of *Pleurotus* (Organisms: Basidiomycetes). Their cap is ordinarily shell-

like (around 5-20 cm in width; 1.97.8 inches), plump, with flighty or horizontal stipe; and their shading can be white, cream, yellow, pink, brownish, or dark grey. As essential decomposers being able to corrupt lignocellulose, oyster mushrooms (*Pleurotus spp.*) are tracked down filling in the wild on the dead natural matter from tropical and oyster locales.

Experimental development of *Pleurotus* began around 1917 in Germany, utilizing normal generate for immunization of wood logs and stumps. The primary enormous scope development on logs was accomplished in Hungary in 1969, afterward an assortment of lignocellulosic side-effects from farming or ranger service were additionally found to be acceptable developing substrates, and a few animal groups were brought into development all through the world, for example, the tree oyster (*P. ostreatus*), the grey oyster mushroom (*P. sajorcaju*), the abalone mushroom (*P. cystidiosus*), the white oyster mushroom (*P. florida* nomen nudum), the golden oyster mushroom (*P. citrinopileatus*), the pink oyster mushroom (*P. flabellatus*), and (*P. sapidus*) the black oyster mushroom. As of now, *Pleurotus spp.* is the second most significant developed mushroom as far as world creation. *Pleurotus* species have been utilized by human societies all around the world for a long time. These mushrooms are additionally palatable and are extremely gainful for the body that breaks the deadly substance. They are one of the most flexible on the planet. These are additionally extremely delightful and arrive in a wide range of shadings. These are the effortlessly developed and contribute greatest to all the mushroom creations (Martínez- Carrera, 1998). Table-2 and Fig.1 explain the workflow for Oyster mushroom production.

Nutritional and medicinal attributes of oyster mushrooms

The protein content of oyster mushrooms can be considered their real dietary quality. Normal values range from 10.5-30.4%, on a dry weight premise. The centralization of fundamental amino acids fluctuates from 33.4-46.0 grams/

100 grams of amended unrefined protein, showing huge measures of lysine, leucine, and methionine. The fat substance detailed is 1.1-2.2% on a dry weight premise, having a high extent of unsaturated fats (79.3%). The carb content differs from 46.6-81.8% on the dry-weight ground. Principle nutrients present in a 100 g dry load of oyster mushrooms are thiamine (1.16-4.80 mg), niacin (46.0-108.7 mg), and ascorbic corrosive (7.4 mg). Fiber (7.4-27.6% on a dry weight premise), and minerals (potassium, phosphorus, iron, copper, zinc) are additionally present to great extent. A few mixtures from oyster mushrooms, conceivably gainful for human wellbeing, have been isolated and examined: 1) Polysaccharides showing solid antitumor movement, 2) A lectin called pleurotolysin with hemolytic properties, and 3) Extracts with hypotensive activity shown improved renal functions (Martínez- Carrera, 1998).

Portobello mushroom

It is one of the largest-sized mushrooms. It has a level cap, with close to dark gills in the cap. It has an exceptionally rich splendid, substantial surface and flavor which forestall it subsequent to cooking. It is the regular wellspring of vit-D. The measure of vit-D relies upon the measure of openness to UV light. Portobello variety of *Agaricus bisporus* mushrooms is very much known for its taste which makes it desirable to be eaten fresh and also as flour in soups and gravies. *Agaricus bisporus* Portobello mushroom, regularly abbreviated to Portobello, is just the completely developed type of the crimini mushroom, which thusly is a variety of the normal developed white mushroom. The name "Portobello" started to be utilized during the 1980s. The Portobello, an incredibly enormous and dim earthy-colored mushroom, whose breadth can undoubtedly quantify 6 inches, has an open, level cap. It has a sensitive character and makes a thick, substantial surface. Its mushroom stipe, normally known as the stem, is utilized in soups and stocks, furthermore, the mushroom pileus, usually known as the cap, is especially barbecued and utilized in a sandwich, or cut into thick cuts for a salad or dish (Khatua et al., 2019).

In a 100-gram serving, rough white mushrooms give 93 kilojoules (22 kilocalories) of food energy and are an incredible source (> 19% of the Daily Value, DV) of the vit-B, riboflavin, niacin, and pantothenic destructive. Fresh mushrooms are additionally a decent source (10–19% DV) of the dietary mineral phosphorus, while new *A. bisporus* just holds back 0.2 micrograms (8 IU) of vit-D as ergocalciferol (vitamins D2), the ergocalciferol content increments are seen significantly after it is exposed to UV light (Wang et al., 2018). Organically talking, crimini mushrooms are just the earthy colored form of the normal white developed mushroom. The more modest, white button mushroom is the most youthful assortment, and the bigger, portobello mushrooms are more established.

Milky Mushroom (*Calocybe indica*)

Building infrastructure for the commercial production of mushrooms, especially in hot, humid tropical areas, is usually expensive because the majority of edible mushrooms have ideal growth conditions at lower temperatures (25°C) (Thakur and Singh, 2014). From the various studies, it has been noted that identifying and growing edible mushrooms were difficult in warm-weather (30 ~38°C) conditions except for the availability of lowcost labor. One of these standardized commercial production methods for the mushroom is for milky white mushroom (*Calocybe indica*)

(Krishnamoorthy et al, 2000). In India earliest report of milky white mushroom production was reported from Tamil Nadu Agricultural University in Coimbatore in 1998. This mushroom variety increased commercial production over the past ten years in India and has improved rural livelihoods (Krishnamoorthy et al, 2000). The first account of *Calocybe indica*, a wild mushroom, also known as "Dhuth chatta," appeared in India. People from West Bengal have been gathering these mushrooms for many years and selling them in nearby markets. Customers get attracted by its sturdy nature and milky white tint (Vikineswary and Chang, 2013). In tropical and subtropical areas of India,

particularly in the plains of Tamil Nadu and Rajasthan, milky white mushrooms are commonly spotted growing on humus-rich soil in agricultural fields or by the side of the road. Between May and August of each year, when there are typically enough showers following a protracted dry spell, the fruiting body of these mushrooms emerged out above the ground (Purkayastha, 1984). *C. indica* are mostly grassland species that are saprophytic in nature and occasionally associated as ectomycorrhiza with different tree species. Extensive studies on the growth parameters such as pH, temperature, carbon and nitrogen ratio (C: N), light, and substrate have been carried out for optimum production of *C. indica*. Due to its physical resemblance to the button mushroom, *Agaricus bisporus*, this mushroom has grown acceptability not only in India but also in other countries of southern Asia (China, Malaysia, and Singapore). Due to the several factors smallscale mushroom producers favor this tropical mushroom: (1) less contamination from competing moulds and insects during crop production under controlled conditions. (2) best suited to warm (30~38°C), humid climates (80% to 85%). (3) Longer shelf life without refrigeration (can be stored up to 7 days at room temperature). (4) Retains fresh look and does not turn brown or dark black like that of button mushrooms. This mushroom has a short crop cycle of 7 to 8 weeks and a good biological efficiency of 140 percent, all these factors which make industrial production desirable. It also has very reasonable infrastructure requirements and relatively low production costs. Since the late 1990s, several changes have been made in production techniques to grow this fungus on a commercial scale (Krishnamoorthy et al, 2000). Spent mushroom substrate (SMS) can be utilized as a brilliant natural compost or for vermicomposting. It is a brilliant palatable mushroom with high fiber (Sardar et al., 2020).

Commonly cultivated mushrooms and their medicinal advantages.

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Trametes versicolor has been displayed to advance chemopreventive potential; it hinders the development of a few human malignant growth cell lines, goes about as an adjuvant in bosom disease counteraction and has huge IC50 esteem (Moulton et al., 2019). *Grifola frondosa* has anti-cancer properties, especially in human gastric carcinoma, such impact results from the acceptance of cell apoptosis and could altogether speed up the anticancer activity (Inoue et al., 2013).

Cordyceps sinensis contains substances called cordycepin, cordycepic corrosive, with helpful applications like the impacts of expanded oxygen usage, ATP creation, and adjustment of glucose digestion. In addition, it has an antibacterial capacity, diminishes asthma, and brings down circulatory strain. Then again, it has been accounted for as organ defender, just as with a defensive impact for heart, liver, and kidney infections. Additionally, *C. sinensis* has a narcotic impact on the focal sensory system (Zhou et al., 2009).

Panellus serotinus (Mukitake) is incredibly considerable in Japan as quite possibly the most flavorful eatable mushroom. The utilization of this parasite assists with forestalling the advancement of nonalcoholic greasy liver illness (Nagao et al., 2010).

Most *Auricularia* species are consumable and are filled industrially in China. *A. polytricha* has likely therapeutic properties and is considered successful to lessen LDL cholesterol and aortic atherosclerotic plaque; it likewise has antitumor and anticoagulant exercises. Plus, *A. auricula-judae* is a famous fixing in numerous Chinese dishes; it has been utilized as a blood tonic and has shown antitumor, hypoglycemic, anticoagulant, and cholesterol-bringing down properties (Reza et al., 2015).

(*Agaricus bisporus*) exhibits antiproliferative and proapoptotic properties and inhibits prostate

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Table: 1 Content of major mineral elements in mushrooms(wild), (g/kg of dry matter)

Elements	Usual contents	Reference(s)
Calcium	0.1-0.5	(Kalač, 2013)
Sodium	0.1-0.4	
Potassium	20-40	
Magnesium	0.8-1.8	
Phosphorous	5-10	
sulfur	1-3	

Table: 2 Cultivation of oyster mushroom (work done from the first day till harvest)

Stages	Days
I. Preparation of medium for mushroom growth	1 st day
II. Sterilization of straws	2 nd & 3 rd day
III. Shade drying of straws	4 th day
IV. Placement of spawns along with the straw in a ring form (peripheral area) in the polybags. Make small holes in that bag for proper aeration.	5 th day
V. Place it in a sanitized dark and covered place. Maintain the temperature(20°23°c) and humidity (70-80%).	5 th day
VI. Water droplets seen in the inner side of the plastic bag	6 th day
VII. White threads of mycelium seen at some places.	9 th day
VIII. Bag is fully covered with white mycelium maintain the humidity level.	12 th day
IX. Fruiting starts, small pins start appearing	22 nd day
X. Pins rapidly grown to large mushrooms	28 th day
XI. Harvesting was done	30-32 nd day
XII. Second harvesting	39-40 th day



Fig. 1 Different processing steps involved in mushroom production.