



MUSHROOM CULTIVATION AND MARKETING



RESEARCH STUDY
Planning & Research Department

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1. INTRODUCTION

Diversification in any farming system imparts sustainability. Mushrooms are one such component that not only impart diversification but also help in addressing the problems of quality food, health and environment related issues. One of the major areas that can contribute towards goal of conservation of natural resources as well as increased productivity is recycling of agro-wastes including agro-industrial waste. Utilizing these wastes for growing mushrooms can enhance income and impart higher level of sustainability.

Commercial production of edible mushrooms bioconverts the agricultural, industrial, forestry and household wastes into nutritious food (mushrooms). Indoor cultivation of mushrooms utilizes the vertical space and regarded as the highest protein provider per unit area. This hi-tech horticulture venture has a promising scope to meet the nutritional requirements without undue pressure on land.

Mushroom farming today is being practiced in more than 100 countries and its production is increasing at an annual rate of 6-7%. In some developed countries of Europe and America, mushroom farming has attained the status of a high-tech industry with very high levels of mechanization and automation. Present world production of mushrooms is around 3.5 million tonnes annually as per FAO stat and is over 25 million tones (estimated) as per claims of Chinese Association of Edible Fungi. The wide variation in world production data in FAO stat and CAEF is partly due to the fact that in FAO stat, mushroom means button mushroom (*Agaricus* spp.) along with the boletes, morels and tuber, whereas CAEF data covers all types of mushrooms. China alone is reported to grow more than 20 different types of mushroom at commercial scale and mushroom cultivation has become China's sixth largest industry.

Presently, three geographical regions— Europe, America and East Asia contribute to about 96% of world mushroom production. With the rise in the income level, the demand for mushrooms is bound to increase in other parts of the world as well. China has been producing mushrooms at very low costs with the help of seasonal growing, state subsidies and capturing the potential markets in the world with processed mushrooms at costs not remunerative to the growers in other mushroom producing countries.

Mushroom is considered to be a complete, healthy food catering nutritional requirements of all age groups. The nutritional value of mushroom is affected by numerous factors such as species, stage of development and environmental conditions. Mushrooms are rich in protein, dietary fiber, vitamins and minerals. The digestible carbohydrate profile of mushroom includes starches, pentoses, hexoses, disaccharides, amino sugars, sugar alcohols and sugar acids. The total carbohydrate content in mushroom varied from 26-82% on dry weight basis in different mushrooms. The crude fiber composition of the mushroom consists of partially digestible polysaccharides and chitin. Edible mushrooms commonly have insignificant lipid level with higher proportion of polyunsaturated fatty acids. All these result in low calorific yield from mushroom foods.

Mushrooms do not have cholesterol. Instead, they have ergosterol that acts as a precursor for Vitamin D synthesis in human body. Similarly, ergosterol in button mushroom is converted into vitamin D₂ when exposed to UV radiation or sunlight. The protein content of edible mushrooms is usually high, but varies greatly.

2. ECONOMIC AND SOCIAL IMPACTS

Since mushroom cultivation can be a labour-intensive agro-based activity, it could have great economic and social impact by generating income and employment for both women and youth, particularly in rural areas in developing countries. Using China as an example, in 1978 the total production of mushrooms in China was only 60,000 tonnes, which accounted for less than 6 percent of total world mushroom production. In 2006, however, total production of mushrooms in China reached 14 million tonnes and accounted for over 70 per cent of total world mushroom production. The mushroom industry can also have even broader positive spill-overs, generating complementary employment in areas such as accommodation, restaurant services etc. Local mushroom industry can also be the main source of revenue for local government.

The following statements summarize the significance of mushrooms in a drive towards alleviating poverty, enhancing human health, and arresting environmental degradation:

(1). Mushrooms can convert lignocellulosic waste materials into a wide diversity of products, which have multi-beneficial effects to human beings, e.g., as food, health tonic, and medicine, as feed, as fertilizers, and for protecting and regenerating the environment. In addition, mushroom cultivation can positively generate equitable economic growth. The tropical regions, particularly, have a wet and warm climate and have an abundant supply of agricultural wastes. These materials are resistant to natural biological degradation because they contain mainly cellulose, hemicelluloses and lignin. Mycelia of mushrooms can excrete enzyme complexes which can directly attack/degrade these components of lignocellulosic materials. Therefore, mushrooms can use these wastes as nutrients for their growth and in the process become food and medicine for human consumption.

(2). Mushrooms are relatively fast growing organisms. Some tropical mushrooms can be harvested and consumed within 10 days after spawning. By the use of different varieties, mushrooms can be cultivated year round. They can be cultivated by using primitive farming techniques in rural areas or by using highly industrialized technologies in the urban and other communities.

(3). Mushroom cultivation can be labour intensive. Thus the activity can generate new jobs, especially in tropical or less developed countries.

(4). While land availability is usually a limiting factor in most types of primary production, mushroom cultivation requires relatively little space. Actually they can be stacked using shelf like culture systems.

(5). Mushrooms have been accepted as human food from times immemorial, and can immediately supply additional protein to human food. Other sophisticated and unconventional sources of food protein, such as yeast, uni-algal cultures and single-cell proteins have relatively more complicated requirements, and need to be processed before they can be consumed.

(6). Edible mushrooms should be treated as healthy vegetables. After improving the cultivation techniques, they should be cultivated as widely and as cheaply as other common vegetables, which will thus be beneficial to the general public.

(7). In view of their pleasing flavor, their high protein, and tonic and medicinal values, mushrooms no doubt represent one of the world's greatest untapped resources of nutritious and palatable food for the future.

3. MUSHROOM GROWTH

Production of mushrooms is completely different from growing green plants. A person considering mushroom production should become thoroughly familiar with the life cycles of fungi. A plant pathology text is a good resource for this initial research task. Mushrooms do not contain chlorophyll and therefore depend on other plant material (the "substrate") for their food. Commonly cultured mushrooms are saprophytes, plants that feed on dead plant material. The part of the organism that we see and call a mushroom is really just the fruiting body. Unseen is the mycelium, tiny threads that grow throughout the substrate collecting nutrients by breaking down the organic material. For different species of mushrooms, the preferred growing medium varies. Some species can grow on a wide range of materials and others can't. After the mycelium has grown throughout the substrate, and when its specific requirements are met, the mushroom will fruit. Humidity, light, temperature, and carbon dioxide to oxygen ratio are conditions which typically determine when a mushroom will fruit.

Nearly the entire common button mushrooms (*Agaricus* spp.) produced commercially in the United States is grown in expensive, high-tech structures designed to minimize pest pressures and to control the growing environment. Managers control not only temperature, humidity, and light, but also ratios of gases in the atmosphere. The production systems are highly developed and very efficient. The goal is always to decrease the time it takes to proceed from prepared substrate to fruiting and harvest. When cycles are shortened, production per year increases and potential profits rise. Typically, the mushroom farmer manipulates the atmospheric conditions first to favor mycelium growth until it fully occupies the substrate. Later the atmospheric conditions are changed to those necessary to initiate and complete fruiting (usually different from those ideal for mycelial growth).

4. BASIC REQUIREMENTS FOR MUSHROOM GROWTH

Temperature:

The heating and cooling system can regulate the temperature as per requirement.

Humidity:

Near about all types of mushrooms grow well with in range of 80-95% humidity that could be arranged with the help of desert room cooler and or sprinkling water near the mushroom beds.

Light:

Most of the mushrooms grow well at normal natural light but oyster mushroom needs regular light that could be arranged through tube lights.

Walls, ceiling, benches and flooring:

Concrete flooring with good drainage would be the best, otherwise, must be made with such type of a material that can be washed and withstand high humidity.

5. BEGINNERS GUIDE FOR MUSHROOM GROWTH

The choice of which species to grow should be thoroughly researched. The beginner should be completely familiar with the various fungi life cycles and should know the parameters of growth required by each. Two basic references are: *The Mushroom Cultivator* by Stamets and Chilton and the aforementioned *Growing Gourmet and Medicinal Mushrooms* by Stamets.

A mushroom cultivation kit is often a good way to learn how to grow a particular species before beginning commercial production. Accurate technical and financial records can be used to realistically gauge whether or not commercial production will be profitable. At the same time, a system for creating conditions favorable to the various stages of growth can be designed and tested.

For a commercial operation, the producer must first collect the substrate material into which the chosen species will grow. Mushroom species are often very particular about their substrates. The substrate is fermented, pasteurized, or sterilized in order to prevent or reduce competition from fungi other than the chosen species. The growing medium is then inoculated with spawn.

6. CHOOSING A MUSHROOM SPECIES

Having access to an economical growing medium suitable to the species chosen is an important factor in deciding which species to grow. The amount of processing necessary to prepare the substrate for the spawn is another consideration. The final choice of a species to grow depends upon the waste materials available for use as substrate, an appropriate facility, cost of necessary equipment, the level of skill required to manage the life cycle of the fungus, and the

market already established for that species. Considering these criteria, oyster (*Pleurotus* spp.) and shiitake (*Lentinus edodes*) mushrooms are probably best for most novices. They are relatively easy to grow and there is a growing market, thanks mostly to efforts of large commercial producers of white button (*Agaricus*) mushrooms who have been diversifying into other specialty mushrooms.

Although these experienced and highly capitalized operators create stiff competition, there may still be a place in the market for the small but efficient producer. Excellent service, top quality, and consistent supply might substitute for the lowest wholesale price with some local customers, particularly gourmet chefs. In addition, shiitakes grown on logs may develop into a separate niche market, because they are considered to be of higher quality and may have a longer shelf life than shiitakes grown on sawdust substrates (the most common mass-produced method). Oyster mushrooms, with limited shelf life, may also have an advantage in nearby markets.

7. MUSHROOM CULTURE AND SPAWN

The propagating material used for mushroom cultivation is called spawn. It is equivalent to the seedlings developed from seeds of higher plants as in case of vegetables. Actually, the spores (serve as a mean of seed) of the mushrooms are so small and could not be seen with naked eye; therefore, the mushroom grower cannot handle them. Technical laboratory person could inoculate sterile cereal grains with the spores or pure mycelial culture of the mushroom and incubate that until a viable product is developed. The grains become "spawn" and can be sown like seed. The entire operation (preparation of pure culture and spawn to spawning) begins in a laboratory under sterile/ aseptic conditions. The best spawn can be prepared on sorghum grain but other cereal grains as well as all agricultural and industrial wastes can also be used.

8.SUBSTRATE

Different agricultural and or industrial straw wastes can be used for cultivation of mushrooms. Mostly, the wheat, paddy, barley, oat and gram straw, banana, sugarcane and maize leaves, empty millet heads and corn cobs, cotton waste, thin sticks and boll locules, sugarcane baggage, banana pseudo-stems, saw dust, logs, straw papers, manure etc. can be used as substrate (medium) for cultivation. The Pakistan is an agricultural country; therefore a huge quantity of the crop wastes is easily available at low cost, which could be converted in to edible mushrooms.

9. CULTIVATION OF MUSHROOM

Mushrooms absorb oxygen and exhales carbon dioxide, do not need direct sun light and open field; but this does not mean that these grow only in dark. Different artificially cultivated mushrooms need different range of temperature, humidity, light and ventilation. The nature has gifted most suitable environmental conditions from sea level to high mountains, where

various kinds of mushrooms grow naturally, but cannot be grown year after year with full commercial excess, unless proper growing conditions are provided and adequate facilities are available. Simple, economical and commercial methodology for cultivation of some known edible mushrooms has been evolved. They can be cultivated in green houses, growth chambers, ditches, caves, huts, hovels, cottages, cellars, garages, sheds or shelters, bee hive shaped huts, thatched or meted roofs, thick tree groves and gardens, kitchens, bathrooms or other extra rooms of a house or any other vacant building.

9.1. Cultivation of Oyster Mushroom

The oyster mushroom (*Pleurotus* spp.) is amongst most important commercially grown mushrooms, now a day in competition with button mushroom, *Agaricus bisporus*. This mushroom resembles the shape of shellfish, therefore mostly known as oyster mushroom in English, Sipi Khumbhi in Sindhi and Sadafnuma Khumbhi in Urdu; also called as wood mushroom, dhingri, henda, kharari, shooto, meat of the forest etc, It is consumed as a fresh as well as dried

Most of the *Pleurotus* spp. is easy to cultivate, need less expenses and care than all other artificially cultivated mushrooms. Best spawn can be prepared on sorghum (jowar) and other cereal grains. Mostly the wheat, paddy, barley, oat and gram straw, banana, sugarcane and maize leaves, empty millet heads and corn cobs, cotton waste, small and thin sticks and boll locules, sugarcane baggage, banana pseudostems, saw dust, logs, waste news papers, manure etc. are used separately or in combination as substrate (medium) for cultivation.

The paddy straw, leaves of different crops and empty corn cobs needs chopping in to small pieces of about 3-5 cm. Threshed wheat straw, cotton waste, cotton boll locules and empty millet heads or so, may directly be used. All substrates needs soaking in water for 24 hours. After soaking, boil the same in water for about half an hour, so that substrate become moist and insect pests and other microbes present in the substrate may be killed. After this, take out the straw from water and spread on the inclined cemented floor, for cooling as well as removing of excess water from the substrate. When the temperature drops down to about normal and moisture content becomes about 80%, the spawn be mixed at 10-20% of the substrate dry weight (which will be 100-200 g /kg of dry substrate). The spawned substrate may be filled in polythene bags and be placed in spawn running room under controlled temperature, humidity and light. This mushroom requires 80 to 95% humidity, 15 to 30 °C temperature and white florescent light for growth and development. When pinheads (initial growth of fruiting bodies) of the mushrooms appear, open the mouth of the bags or cut at place, to facilitate the growth of fruiting bodies. Sort out the contaminated bags and destroy them away from the growing space, burning of such bags is safe for remaining crop.

9.2. Cultivation of Straw Mushroom

The straw mushrooms belong to genus *Volvariella*, grow best on paddy straw, and therefore are called straw or paddy straw mushrooms. Perhaps it was first time identified as edible, greatly consumed by Chinese and its cultivation was started in China, therefore is also known as Chinese mushroom, tributary mushroom or nanhua mushroom. This mushroom stood third popular mushroom, can be consumed as fresh as well as dried. Different agricultural and industrial straw waste, recommended for the cultivation of oyster mushroom, can be used for spawn preparation and cultivation, but remember that the paddy straw proved the best.

The straw mushrooms are mostly cultivated on beds, prepared by two ways. The beds from chopped, soaked and boiled straw are prepared of about square meter size, by placing the moist straw in such a way that first layer be of about 4 inches. In this case, place the spawn 3-4 inches inside the margin of layer at 4-5 inch distance from each other. Sprinkle small quantity (1/2 teaspoon) of gram flour, over the spawn. The second and third layer should be prepared and spawned in the same way. The last layer should be covered with a thin layer and polythene sheet.

In case of cultivation on beds of un-chopped paddy straw, banana leaves etc; the bundles should be prepared of the size of available straw or leaves. If the bundles are prepared from banana leaves than the soaking may be done for 4 hours otherwise for 24 hours. The soaked bundles may be arranged on inclined cement, till the discharge of excess water, before preparation of beds. The bundles are placed length wise, close to each other, on cemented floor, in a cross fashion, with the opposite but ends on one side. Each bed may not be more than five layers. All layers spawned and finally be covered as that of discussed above. In case of cultivation in bags, the same procedure is adopted as described for cultivation of oyster mushroom; only temperature, water and light requirements need change. When the pinheads or small buttons of the mushroom appear, the polythene bags be chalked with blade and sheets should be removed, to facilitate the pinheads for further growth. The straw mushroom requires 80 to 95% humidity, 30 to 35°C temperature and at least two times watering.

9.3. Cultivation of Button Mushroom

The white mushrooms, resembling with the shape of button are mostly known as button mushroom, but as these are naturally grown in meadow, therefore are called meadow mushrooms, also known as European mushroom, town or street mushroom in Europe. These are largely grown and greatly consumed throughout the world with almost 80 percent share among growing mushrooms.

The button mushroom is difficult to cultivate, need many more expenses and long time than other artificially cultivated mushrooms. Rice husks or wheat grains found to be the best for spawn preparation, but needs different types of composts with different compositions for cultivation. The process of compost making is termed as composting. The biochemical activity

of a number of microorganisms for making the substrate selective for growth of mushroom is called compost. The term composting is also defined as indefinite microbial degradation of organic wastes. The wastes includes vegetable and animal material, forest litter, remains of stubbles and roots in the soil, sludge, animal manure etc. However, this mushroom can be grown successfully in cellars, garages and in any abandoned room. The cultivation in mushroom growing houses by mean of tray system proved to be best. Casing is another exercise, which is also compulsory during cultivation process. Casing means the covering of compost with a thin layer of soil or soil like composted material after the spawn has spread in the compost (till the completion of spawn running). 4-6 air changes or introducing 10 cubic foot fresh air (ventilation) per square foot bed area per hour is also necessary for good crop, but this is the very risky due to opening entries of growth rooms and helping insect pests and pathogen to attack on crop. Meanwhile, 80 to 95% humidity, 15 to 25°C temperature and time to time watering is also its basic requirement for normal growth and development.

9.4. Cultivation of Desert Mushroom

Most of the illiterate people are of opinion that desert mushroom is gifted from almighty Allah; rain is a seed of it. Actually, the dark brown to black powdery mass, developed in mature mushrooms, is a huge quantity of spores, which are not seeds, but serve as a mean of seed. Only Arora (1986) claimed that "I have personally worked with this mushroom and have had no problem".

The desert mushroom can also be cultivated artificially, as easily as that of other cultivated mushrooms with a little difference. It does not need tissue culture or artificially prepared spawn, but only matured mushroom spores can directly be used for sowing purpose. The results show that there is no need of agricultural or industrial waste, nor a process of soaking, boiling or sterilizing of such material is required. On the other hand, it can be simply cultivated on flat bed of soil. Only the need is that select sandy to sandy loam soil in the surrounding of thick grove of trees and or gardens, or ordinary shed be prepared, because direct sun rays are dangerous for this mushroom too. However, small 4x5 feet sized beds may be prepared with about 9 to 12 inches layer of soil and than one soaking dose of irrigation water may be applied. After a day, the mushroom powder (spores of matured mushroom), not older than one year, may broadcast.

The spores may be mixed with the help of log stick, spade or so, on 2 to 3 inches upper surface of the bed. It must be kept in mind that the beds should be under shade (of trees or artificially prepared thatches etc.). The water must be sprinkled/ sprayed just after mixing of the spores and twice a day on the following days, so that the beds remain moist. Normally the crop may appear within 30 days. Initially, the root like threads (or well-developed hypha) develop from the spores, in orders to search for food, which are actually microscopic, but some times are visible. These threads transmit into mushroom, which initially appears very small and milky in color, vary in shape and size but become normal in shape and size, within one or two-three days, depending upon the environmental conditions.

10. HARVESTING, YIELD AND MARKETING OF MUSHROOM

Most of the mushrooms are harvested through picking by hand. The harvesting of oyster mushroom could be done with the help of sharp knife or blade, at the base of the stipe. If there are many pinheads around the mushrooms, cut that mushroom very carefully, so that the near by pins do not be disturbed. Any mature mushroom (harvested or diseased), their stalks and refuse or solid portions left in the bed should be removed and destroyed, to minimize risk of diseases and pests.

The mushrooms yield the crop in cycle and subsequent flushes can be harvested till the conversion of waste in to mushroom or up to contamination or till attack of insect pests or diseases. Approximately, the mushrooms yield equal to 100% of substrate dry weight.

Only some types of wild edible mushrooms e.g. black morels, desert mushroom and button mushroom are being collected, gifted, marketed and eaten by the rural population. These, as well as other artificially cultivated mushrooms could be marketed in local and foreign markets. The marketing or import and export value of mushrooms could be realized from the reports of Export Promotion Bureau.

10.1. Marketing of Mushroom

Marketing is getting the right product, to the right people, at the right price, at the right time and in the right way. Marketing of fresh mushrooms all over the world is not very organized except the auction system in Netherlands. Producers make direct efforts to bring the produce to the super markets and 'wholesale distributor' element is mostly missing. However, trade in the processed (canned and dried) is sizeable and organized.

10.2. Global Scenario

About the mushroom marketing, Stan Hughes said *"Mushroom growers have mystified me for years. They put so much effort into growing and so little into selling"*. For effective and efficient marketing, especially export, it is necessary to understand the global trade vis-à-vis the sources of supply, potential regions of demand and consumption patterns. China, USA, Netherlands, Poland, Spain, France, Italy, Ireland, Canada and UK are the leading producers.

10.3. Markets for Mushrooms

Since the 1950s, per capita demand in the U.S. for the white button mushroom as well as Specialty varieties has increased dramatically. The mushroom industry in the United States is currently dominated by large, well-established companies. Most are located in Pennsylvania and California. The production houses are constantly full of mushrooms in every stage of production. Mushrooms raised in these systems can be sold on the wholesale market and still earn a profit. It is very difficult, however, for a beginning grower to compete with these companies in wholesale markets.

The small-scale commercial production of white button mushrooms and other *Agaricus* mushrooms such as portobellas and creminis may not be economically viable and is not recommended for the beginner. A significant capital outlay and a high level of management skills are required to begin production and, at current prices, recovery of the initial investment may not be possible. Marketing is extremely competitive. More information about the button mushroom business is available from The American Mushroom Institute. Although many mushrooms have been investigated and can be cultivated, the market for specialty mushrooms is still limited. The potential mushroom producer would be wise to thoroughly investigate demand for each species before committing large amounts of time and capital to the production stage of the enterprise development.

Direct marketing at local farmers' markets, restaurants, or supermarkets may be an opportunity in some locations. Most wholesale customers will require assurances of consistent supply and quality before they will commit to purchasing from unknown or less convenient sources.

10.4. Markets Research

Perhaps the most challenging problem in developing new enterprises is assessing the market. Nevertheless, growers are strongly encouraged to assess market opportunities before beginning. When considering growing mushrooms as a diversification strategy, farmers must know the answers to the following questions:

- Is there a market for this? Will I be able to sell enough mushrooms at a price above my cost of production?
- Will growing and selling mushrooms be consistent with my family's goals and my farm business goals?
- Do I have the resources needed to be successful? (A complete inventory should include skills, labor and management time, sources of information, assistance and credit, input suppliers, processors and distributors.)
- Will it be profitable? (Use projected income and expenses for an "average future year" to determine whether revenues will be higher than estimated costs of production.)
- Can I afford to produce mushrooms? (A new enterprise may take several years to become profitable.) The goals in market assessment are: 1) to project the volume of sales and the price to reasonably expect to achieve with a new enterprise, (needed to analyze profitability and cash flow potential); and 2) to gather information about potential buyers and competitors (helps in developing a market strategy).

These next set questions of can be answered through market research:

- What is the total market size at present for this product within a given area?
- How many competitors are there for this market? What are their strengths and weaknesses? What type of buyers are they targeting?
- What prices can buyers expect to receive for a given level of quality?

- What trends are there in consumption, competition, and pricing?
- What are the characteristics of buyers of this product or service? Age? Income level? Lifestyle? What are they looking for? Where are they looking for it? How can I do a better job than my competitors in meeting their needs? What proportion or share of the market might I expect to capture?

10.5. Suggestions for Marketing

1. Expand the market area and strengthen the demand:

- a. Popularize mushrooms using ICT as delicacy with nutritive and medicinal value, on mass media like ads and posters.
- b. Break consumer resistance by creating awareness in new areas. Demonstration of different growing, cultivating and harvesting recipes and free samples in new areas. Free recipe booklet.

2. Form cooperatives for sale:

- a. Create cold storage facility
- b. Create refrigerated transport facility
- c. Create processing facility
- d. Create distributor function for big cities.

3. Decrease the cost of production and bring down the sale price to boost the demand.

4. Good prepacks for eye appeal.

5. Train retailers about handling, storage, food value and recipes.

6. Approach supermarkets, chain vegetable stores, mother dairy retail counters for retail sale.

7. States should fix minimum support price.

8. Public sector marketing, processing and export organizations should come forward.

9. Assured supply throughout the year at a reasonable constant price is key to good marketing. Efforts should be made to diversify and cultivate different mushrooms throughout the year along with cultivating some of the important mushroom during off-season under controlled condition.

10. In a limited area, say a village or a cooperative, the crops should be time-scheduled to get a daily reasonably uniform production to avoid glut on a day, this is required to meet the commensurate demand. One cannot ask consumer to purchase more because all have got a peak flush during a week. The marketing system has to be viewed as a value chain where all components are taken care of. The increased production should get translated into economic gain for mushroom producers. This is possible only when marketing is organized and demand is ensured. Considering that awareness about consumption and health benefits of numbers of mushrooms available for cultivation is limited, their demand is also less. Hence, multipronged strategy is required that means needs to Expand market, Increase demand, organize marketing and Form cooperatives.

11. Concluding Remarks

From what has been presented in the preceding pages, the following summary can serve as concluding remarks:

- Mushrooms can serve as food, as tonic, and as medicine. A regular intake of mushrooms can make you healthier, fitter, and happier. They can make you live longer, and always look younger.
- Mushrooms are biota characterized by wonder. They rise up from lignocellulosic wastes, yet they become so bountiful and nourishing.
- Mushrooms are environmentally very friendly. They bio synthesize their own food from agricultural crop residues, which would otherwise cause health hazards. And their spent composts/substrates can be used as animal feed, bio fertilizers and biogas.
- Mushrooms can serve as agents for promoting equitable economic growth in society.
- They are a unique group of fungi through which we can pilot a non-green revolution in less developed countries, and in the world at large. They demonstrate great potential for generating a great socio-economic impact in human welfare, at local, national and regional levels.
- The aims of the discipline of applied mushroom biology are to tackle the three basic problems: shortage of food, diminishing quality of human health and pollution of the environment, which human beings still face, and will continue to face, due to the continued increase of the world population.
- On the other hand, it has been observed that over 70% of agricultural and of forest products have not been put to total productivity, and have been discarded as waste. Applied mushroom biology not only can convert these huge lignocellulosic biomass wastes into human food, but also can produce notable nutraceutical products, which 55 have many health benefits. Another significant aspect of applied mushroom biology is using the biota in creating a pollution-free and beneficial environment. These three components of applied mushroom biology are closely associated with three aspects of wellbeing – food shortage, human health and environmental pollution. One of the most significant benefits of mushroom cultivation is their ability to create a pollution free and friendly environment.
- For better marketing, market research should be done considering current demand supply trends

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