FAQEER MUHAMMAD, SARANJAM BAIG,
KHALID MEHMOOD ALAM, ATTAULLAH SHAH (Eds.)

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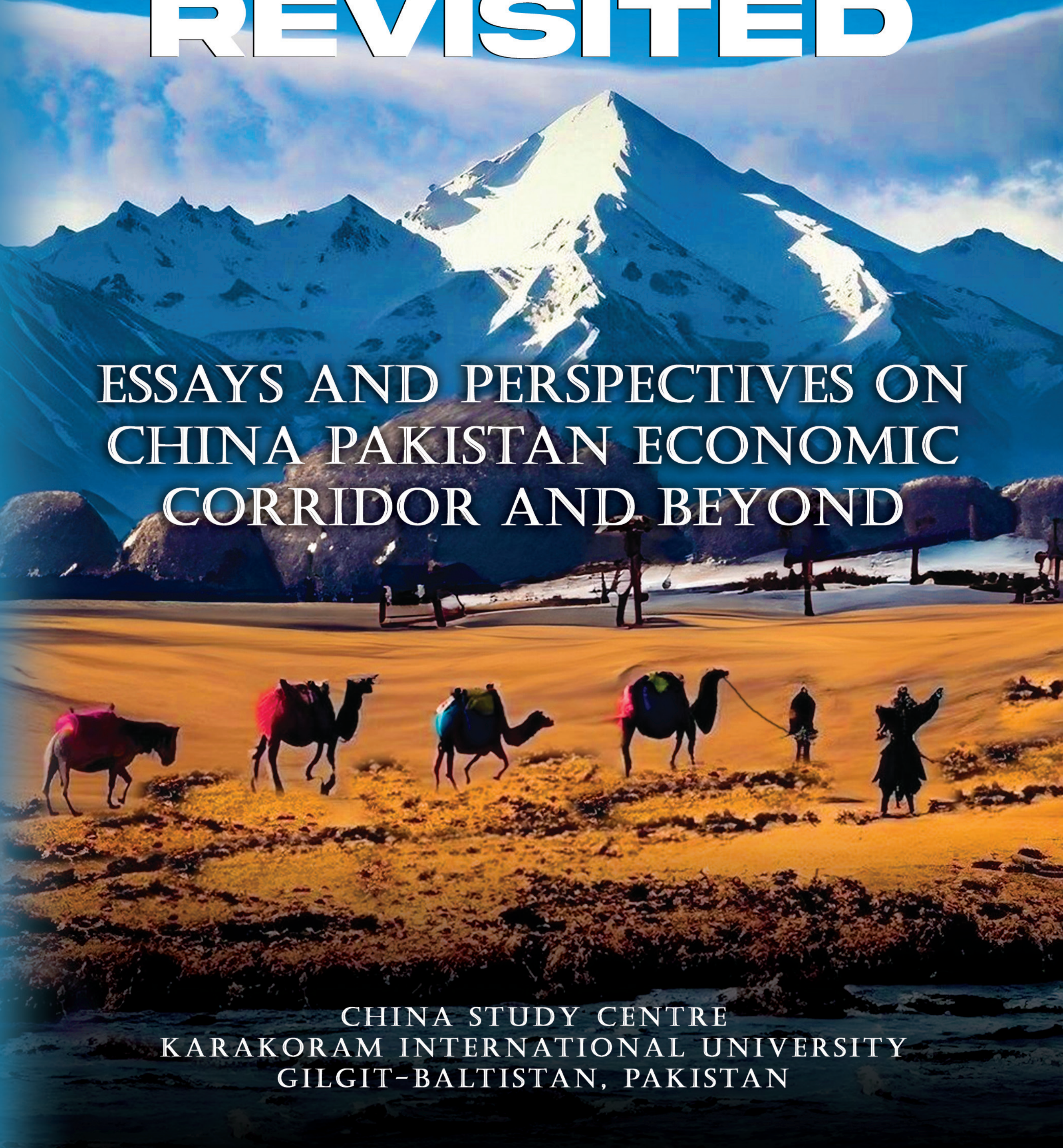
ESSAYS AND PERSPECTIVES ON CHINA PAKISTAN ECONOMIC CORRIDOR AND BEYOND



CHINA STUDY CENTRE
KARAKORAM INTERNATIONAL UNIVERSITY
GILGIT-BALTISTAN, PAKISTAN

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Development of Morel Mushroom Technology in Gilgit-Baltistan: Chinese Experiences in Perspective, A Viable Option for Income Generation

Azhar Hussain
https://orcid.org/0000-0002-5777-2058
Department of Agriculture and Food Technology, Karakoram International University, Pakistan

Sartaj Ali
https://orcid.org/0000-0002-1250-5538
Department of Agriculture and Food Technology, Karakoram International University, Pakistan

Faqeer Muhammad
https://orcid.org/0000-0003-3261-3066
China Study Centre, Karakoram International University Gilgit-Baltistan, Pakistan

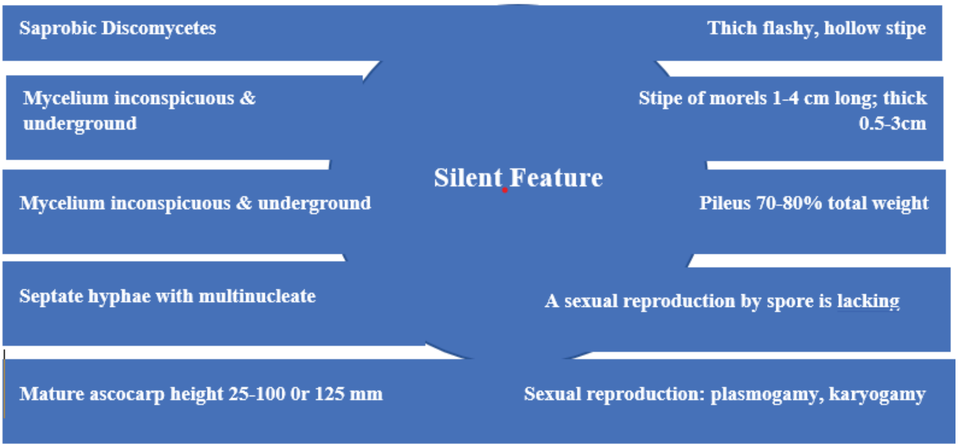
Amjad Ali
https://orcid.org/0000-0002-0894-7755
Department of Agriculture and Food Technology, Karakoram International University Gilgit-Baltistan, Pakistan

Introduction

Mushroom cultivation on compost manure beds in caves and sheds is known since the 18th century. In the later stages, decomposed leaf debris was added to facilitate the fast growth and development of mushrooms (Quimio, Chang, & Royse, 1990). A significant shift in commercial mushroom production occurred in the sixties with the advancement of new technological approaches, the establishment of research laboratories, and global spawn production (Flegg, Spencer, & Wood, 1985). Mushrooms in nature grow on the roots of trees, in the soil as mycelium, which is white in oyster mushrooms (Figure 1). Around two thousand years have passed since the first-time mushrooms were utilized and valued as a delicacy. The first people to cultivate mushrooms were the Chinese. According to published sources, *Auricularia auricula* was initially grown in China in 600 (S.-T. Chang & Miles, 1989; Quimio et al., 1990).

Morchella spp. of morel mushrooms are essential edible commodities with a good taste and attractive appearance (Hibbett et al., 2007). Morel, as an edible fungus, has high consumer market demand and gets a premium price in America and Europe (Stott & Mohammed, 2004). The USDA had approved earlier morel products as food and pharmaceutical items (Gilbert, 1960), while Chinese literature from the Ming Dynasty shows records in the prestigious "Compendium of Mediteria Medica" pharmaceutical text by Li Shizhen used as a remedy for stomach problems. "Guchhi" is a commonly referred name for morels in the Indian markets are considered a high economic value commodity in the Northwest Himalayan range (Lakhanpal, 2010). Available literature and current research progress regarding the genus *Morchella* discuss mainly its diversity, distribution, ecology, phylogeny, taxonomy, genome, and artificial cultivation (Kuo et al., 2012). Due to its immense scientific and economic significance, this genus has been a focus of research in recent years globally as well as in Pakistan. Among the 65 phylospecies of *Morchella;* China or East Asia represent more than half of them (34 spp.), including 20 endemic species. Compared to East Asia; a smaller species diversity is reported from Europe (27 spp.); amongst 12 spp. recorded as endemic (ref). North America represents 21 spp. Moreover, of which about 14 species have been reported as endemic (Du et al., 2012). However, recent data indicate that Morchella species diversity is concentrated in China or East Asia. *Morchella eximia* M. Kuo (Mel-7) is the most widely spread species among the 25% species recorded from Asia, Australia, Europe, South, and Northwestern America, according to reports on the distribution. Among the species of *Esculanta clade*, 60% were reported as endemic in East Asia, while 11% had disjunctive distribution. Contrary to that; a wide distribution was noted in 31% spp. of Elata Clade, and a high species diversity was observed in Europe compared to East Asia (Du, Zhao, & Yang, 2015; Kuo, 2008). Despite tremendous efforts over many years, the cultivation of morel is still a challenging job for researchers and growers. According to (Masaphy, 2010), *Morchella rufobruminae* fruiting body initiation and development have been successful on a laboratory scale. Mushroom growth started to show up two to four weeks after the first watering from the incubated sclerotia at temperatures between 16 and 22 °C and 90% relative humidity. True morels (Morchella spp.) are edible mushrooms with a delicate flavor and distinctive appearance that are commercially significant and are members of the Ascomycota, Pezizomycetes, Pezizales, Morchellaceae, and Morchella Dill families. ex Pers. These genera' species are all edible (Dai et al., 2008). A study team from the Soil and Fertilizer Institute of the Sichuan Academy of Agricultural Sciences in China domesticated *M. importuna* strain SCYDJ1-A1, the first morel variety approved in China, from a wild mushroom that was gathered in the eastern Tibetan Plateau. Given that it has been found in Yunnan, China, Germany, and Turkey on non-burned sites, *Morchella importuna* appears to be a facultative post-fire species (Richard et al., 2015; Taşkın, Büyükalaca, Hansen, & O'Donnell, 2012). The ectomycorrhizal lifestyle of many other species of Morchella, in which affiliations and interactions with plants are frequently necessary at phases, contrasts with its saprophytic nature. For practically all types of mushroom farming, spawn quality is essential. The cultural morphology of Morchella isolation in various growing conditions is erratic and unstable, which emphasizes the challenge in determining spawn quality. Even in China, there are no established quality criteria for morel spawn; instead, quality assessments are based on empirical data, primarily the number of sclerotia. The connection between the development of sclerotia and ascocarps has not yet been studied. There are numerous questions about how to understand spawn production due to the lack of knowledge available on the morel's life cycle, growth, biology, and genetics (L. Chen, HMi, Huang, & Zhao, 2011).

Silent feature and Some Pictorial Atlas of Morel Mushroom



Chinese Contribution in Morel Production Technology

The introduction of exogenous nutritional bags is a significant development in China regarding morel cultivation and production. This idea originates from Owers patent, R.D., who is honored by Chinese scholars as the "Father of Morels." Some scientists from the Sichuan Academy of Forestry, in 2000, found some fruit bodies of morel in a flowerpot being supplied with exogenous nutrition outside their door (Tan, 2016). Further studies revealed that exogenous nutrient supply is crucial for the field cultivation of morel. Scaling up of field cultivation of morel started in 2011, initially at 200 ha and further with a quick expansion to 1600 ha in 2016, as shown in current survey reports from China (Q. Liu, Ma, Zhang, & Dong, 2018).

Morel Species Cultivated in China

Morchella importuna, M. sextelata, and M. eximia are the species that are now grown in China (Du, Zhao, Xu, & Yang, 2016; Wang & Xian, 2013). Based on morphological characteristics and molecular data, the cultivated morels were identified (He, Liu, Cai, & He, 2015). All these species are black morels. M. importuna made up about 80–90% of the cultivated area (W. Liu, Zhang, & He, 2017). The first strain of M. importuna, known as "Sichuan Morel No. 1," was authorized in China. Moreover, Morchella conica can be grown (Du et al., 2016).

Ways of Morel Mushroom Production

Different approaches in morel cultivation have been adopted to meet the growing market demand. Historical evidence of outdoor morel cultivation dates to 1882 in France (W. Liu et al., 2017). Nonetheless, a crucial success took place in 1982 in outdoor morel cultivation when Ower succeeded to grow morels in two basic steps i.e. sclerotia inoculation and supply of exogenous nutrition (Ower, 1982). On top of the soil, which had developed a mound of mycelia, the operator first spread plastic bags with sterile wet scrips. This crude version of the nutrition bag was employed and served as the basis for the later successful artificial growing of morels. In 2005, Gourmet Mushrooms Inc. (Mason County, Michigan, USA) started selling fresh morels that had been grown via a technique based on Miller's patent (Miller 2005), which referred to Ower's patent. However, the indoor growing of morels was stopped in the USA in 2008 due to issues with a lower yield and bacterial contamination (Tan & Ibrahim, 2017).

Methods for Morel Cultivation in the Field

The domestic production has persuaded several farmers, organizations, and policymakers in China and overseas of wild morel mushrooms. A vast range area is suitable for farming morels like farms, forest patches, hilly plains, and mountainous terrains with a dim light of sun. Hence direct sun rays hinder the growth. The cultivation steps included spawn production, land preparation with decomposed organic mulch, spawning, nutrient supply, fruit management, and careful harvest.

Spawn Production

Spawns are mushroom seeds. Like other mushroom cultivation processes, a starter culture, growth medium, and spawns are required to start the cultivation of morels. A variety of starter cultures can be developed from healthy, fresh fruit bodies of morel or acquired from a lab or other source of spawn. More cultures can be prepared from agar for extended production of starter cultures and further extending the large-scale production of spawn substrates. PDA (potato dextrose agar) with other humus is used for basic spawn production and further multiplication. Keeping in view the economical availability and easy access; a variety of raw materials for the preparation of substrates are used like wheat, wheat bran, sawdust, humus, and quicklime. A familiar substrate formula may be wheat, husk, wheat bran, sawdust, gypsum, precipitated sodium carbonate, and humus in the ratios 46, 20, 18, 10, 1, 1, and 4% respectively. Heat-resistant containers (I.e., glass and plastic bottles) are used for initial spawn production. In contrast, heat-resistant plastic bags are used for final spawn production that conveniently facilitates transportation. The required spawn seed rate for cultivation of one hectare is almost 3000-3375kg, comprised of 4500 bags of 14x18 cm. Currently, private spawn producers directly provide spawn at an approximate cost of 52,500 to 75000 RMB (7620 to 10880 USD) to more farmers.

Spawning

Given their aerobic nature, morels thrive in loose soil. Before spawning, it is required to plow the ground and remove extras like rocks. Quicklime can occasionally be used in soil to eradicate pests and balance pH. The mushroom bed should be 15 cm deep and 80–150 cm wide. The beds are about 30 cm apart from one another. Although the morel spawn is immediately placed into the cropland or woodland, comparable to the seeding of wheat crops, the spawning process for morel agriculture differs from that for most other mushrooms. Depending on the elevation, the morel spawning season varies, but it generally lasts from October until the middle of December. When the local maximum temperature reaches 20 °C, spawning usually starts. A range of 50% to 70% soil humidity is maintained. It involves both strewing and seeding in trenches. After spawning, non-nutritive casing soil is equally applied over the spawn at a depth of around 3–5 cm. A cover and film mulching can assist keep the temperature, humidity, and low light levels stable.

Supplemental Nutrients from Outside Sources

Upon spawning, the morel mycelia establish themselves in the soil at an appropriate temperature and humidity, i.e., 20 °C and 50–70% soil humidity. A large area of whiteness that covers the surface of the mushroom bed after 10 to 15 days is known as a “powdery mildew.” The morel mycelia and conidia that grow on the soil are what are visible as this white patch. Then the mushroom bed can be covered with an exogenous nutrient bag. Wheat, chaff, sawdust, and cottonseed hull are some substrates employed in the exogenous nutrition bag. The same recipe can be used to create the final spawn, and some are listed in numerous Chinese patents, such as those for lime 5%, wheat 67%, and sawdust 28%. Exogenous nourishment does not seem to have a very rigid composition. A heat-resistant polyethylene bag is placed into the exogenous nutrition bag and then sterilized. The bag should have holes, or a significant cut made on one side before being firmly positioned in the mushroom bed. Between each one, 50 cm must be maintained, and 22500 to 30,000 bags per hectare are advised. After 15 to 20 days, mycelia will develop inside the bags using the nutrients added externally under ideal conditions. The bags utilizing the provided nutrients are removed after 40 to 45 days. External nutrition support is essential in the technique under discussion for the morel’s ascomata growth; nonetheless, the mechanism is still unknown.

Fruiting Management

Humidity (air) and moisture (soil) are the crucial consideration factors in morel cultivation. Over 50% soil surface humidity is recommended, which can be maintained by spray irrigation to overcome dry heat spells. Good drainage and water supplementation are essential factors for crop management. To produce quality fruit, soil moisture should be kept between 65 and 75 percent and air humidity between 85 and 90 percent. More soil and air humidity is necessary during fruiting. When the springtime temperature rises to 6 to 8°C, water is pumped into the bed trenches to maintain the ideal humidity levels in the air (85–90%) and soil (65–75%). The optimum condition of the surrounding environment speeds up the growth initiation of morel primordium. Cotter 2014 also suggests flooding for field cultivation of morels for stimulation of the growth process and utilization of nutrients suggests and microflora for fruiting. The optimum temperature for primordium development and fruit body setting is 6 to 10°C. Temperatures higher than 10°C are suitable for primordium differentiation. However, an increase in temperature above 20°C restricts the growth of morel fruit bodies. Temperature adjustment in outdoor cultivation can be made through mulching, spraying, and ventilation. Pest control is another important aspect of crop management morels where the eminent threat can be paused by mites, springtails, maggots and limax. At the same time, prominent contaminants are mold and bacteria. Biological and physical control measures are recommended to overcome pests and contaminants, whereas applying chemicals is not recommended.

Harvesting

Harvesting is recommended when the ascocarp develops to 10 to 15 cm with an apparent development of ridges and sinus. Careful handling is a must to retain the physical features of the fruit, and drying or dehydration at a lower temperature is recommended to maintain quality.

Issues and Perspectives

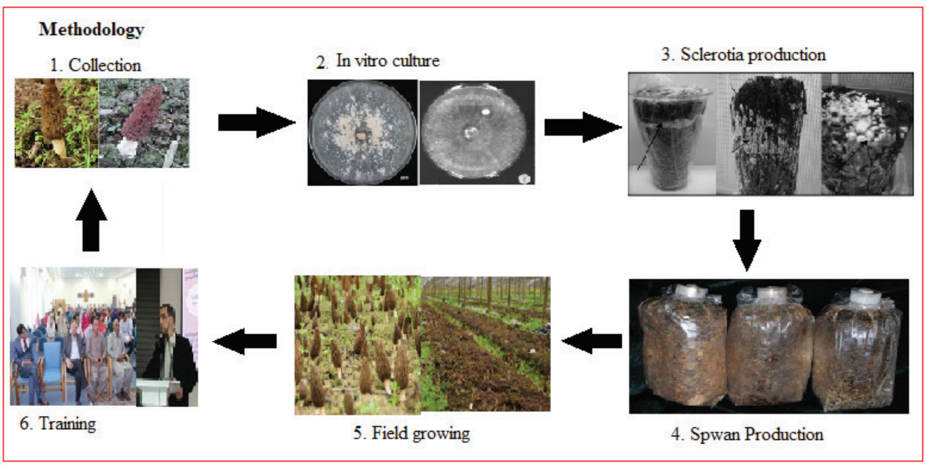
Morels are high prize commodities of immense nutritional and health benefits and are collected by the communities as a source of income to sell in the market. However, its domestication and farming have been successful in recent years in China. However, information and knowledge regarding the growth and development of fruit, especially spawn aging, nutritional requirements, and fruit body initiation, is still insufficient. Systematic research is highly required to solve the unresolved questions and promote scientific techniques to exploit this highly prized natural resource through artificial cultivation to increase the income of farm people.

Life Cycle and Reproductive Systems

Many studies have been carried out on the *Morchella* life cycle. However, knowledge of the formation of sclerotia and the development of ascocarp is still thought of as a complex process to scale up the artificial production of morels. Hence, studies on understanding the life cycle will contribute towards evolving efficient cultivation techniques that help improve the successful production of *Morchella*. Knowledge gaps still exist in understanding conidia development that is important in artificial cultivation. However, no conidia production has been observed in pure cultures under different conditions. Conidia producing mechanism of morels is still unclear, and it cannot develop into fruit when produced outdoors. An intermediate stage of sclerotia formation is required for morel fruit development. However, substrate composition is critical in shaping mycelial characters and sclerotia formation. A particular developmental stage of sclerotia may act as a precursor for the formation of ascocarp. Still, it may also be an organ for storing nutrients looking for suitable conditions to develop into an ascocarp. Experiences from China do not indicate the need of sclerotial formation for development of fruit body. Genetic studies of morel genome will provide a better understanding of various mechanisms regarding reproduction and fruiting through sequencing of related genes of morel. So far, under the 1000 fungal genome project; gene profiling of only two species is complete.

Spawn quality

Quality of spawn for cultivation and exploitation is crucial for all types of mushrooms. The spawn quality evaluation of Morchella isolates is complex as their cultural morphology varies about growth media since it is unstable and random. Besides, no agreed standards exist in China for spawn quality, and producers determine quality on their observations relying on the number of sclerotia produced. Sclerotia and ascocarp development are related but this has not been studied yet. Hence, clear information and knowledge on biology, especially genetics and developmental phases of the morel life cycle, is lacking, which has left many facts unturned related to spawn quality.



Business Opportunity

Most of the population in Gilgit-Baltistan is involved in agriculture, with about 80% of the population relying on it for their livelihood. Agriculture is traditional and subsistence-based, focusing on fruits and a small number of high-value cash crops. Farmers are generally from low-income families with limited land holdings and little knowledge of technology. Even though agricultural development has long been a focal focus of national strategies for poverty alleviation and economic progress, there is still a lack of execution, proper research, and study in this subject. Gilgit- Baltistan's biodiversity is also noteworthy, with a diverse range of plants and fauna. This allows for the development of various high-value items, including mushrooms. The potential for mushroom production for culinary and medicinal purposes is enormous due to this rich diversity. Because cultivated areas are fewer than one kanal per capita, the inhabitant is completely reliant on wheat supplied by the government at subsidized rates. Fruits and vegetables are the only source of income, but pre-and post-harvest losses of fruits and vegetables are between 50 and 70 percent. However, the diversity and technological involvement have provided resources that have yet to be harnessed and utilized. In this context, the only way to raise rural income and achieve a competitive structure for agriculture to increase job possibilities and growth is through innovation and diversification in agricultural systems. Furthermore, small family farms are disadvantaged because they lack sufficient area to grow crops and raise livestock. The greatest solution for dealing with these difficulties and ensuring the long-term development of rural community mushroom production is rural community mushroom production. The mushroom output might be significant if non-agricultural work and income options are available. Because small family businesses may not have enough acreage to grow crops or rear animals, intensive mushroom growing could be an excellent alternative source of income. This project focuses on the advancement of indigenous mushroom farming technology.

Competitive Analysis

Through economic, nutritional, and therapeutic benefits, mushroom growing plays a critical role in improving the well-being and livelihood of rural people. The study's findings may be valuable in developing ways to reduce poverty and assure food security for the community, academics, researchers, and government planning organizations. Mushroom production is the only option for poverty reduction and rural development in the region because of its high nutritional value and high price.

Innovation/Unique Selling Points

Morel mushrooms have a high commercial worth that has been recognized worldwide. Wild morels are harvested in significant numbers in China, India, Pakistan, Turkey, and North America. Food security is an issue in Gilgit-Baltistan, which is expanding. Because each person has less than one Kanal of arable land, they are entirely dependent on the government's subsidized wheat supply. The only source of income is from fruits and vegetables, although pre- and post-harvest losses range from 50 to 70 percent. It is the finest option to explore developing indigenous mushroom production technology. The region's farming community can be empowered to improve mushroom technological production skills, which could become a major source of income soon. This initiative aims to pool information on morel mushroom collecting, identification, and production technique to provide a new window to the mountain community interested in mushroom growing. This project will benefit all individuals who want to learn about and start mushroom cultivation, including producers/entrepreneurs, researchers/scientists, and marginalized farming communities who want to start or incorporate it into their current agricultural system.

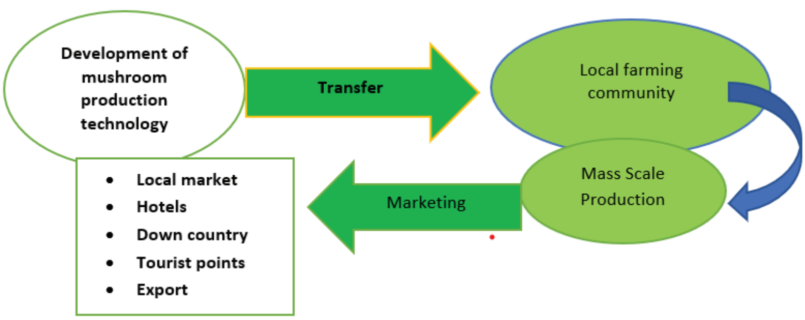
SWOT Analysis

Strengths: Morel is a scarce seasonal variety of mushrooms mainly found in Gilgit-Baltistan: Kashmir and some other parts of Pakistan. Significant earnings from a mushroom-growing operation can be realized in a matter of weeks. Also, building your profitable mushroom farm is simple. Gilgit-Baltistan has every kind of season and climatic conditions congenial for mushroom production.

Weaknesses: In Gilgit-Baltistan, it has many issues due to which we have no production technology for mushrooms. Primarily lack of public awareness, marketing technical knowledge and the perishable nature of mushrooms.

Opportunities: Alternative farming option, income generating source and new window for landless people and source of poverty reduction. This may be covered by the high protein and rich nutrients through mushroom. It is a source of employment generation. Small farmers and landless farmers have a wonderful opportunity.

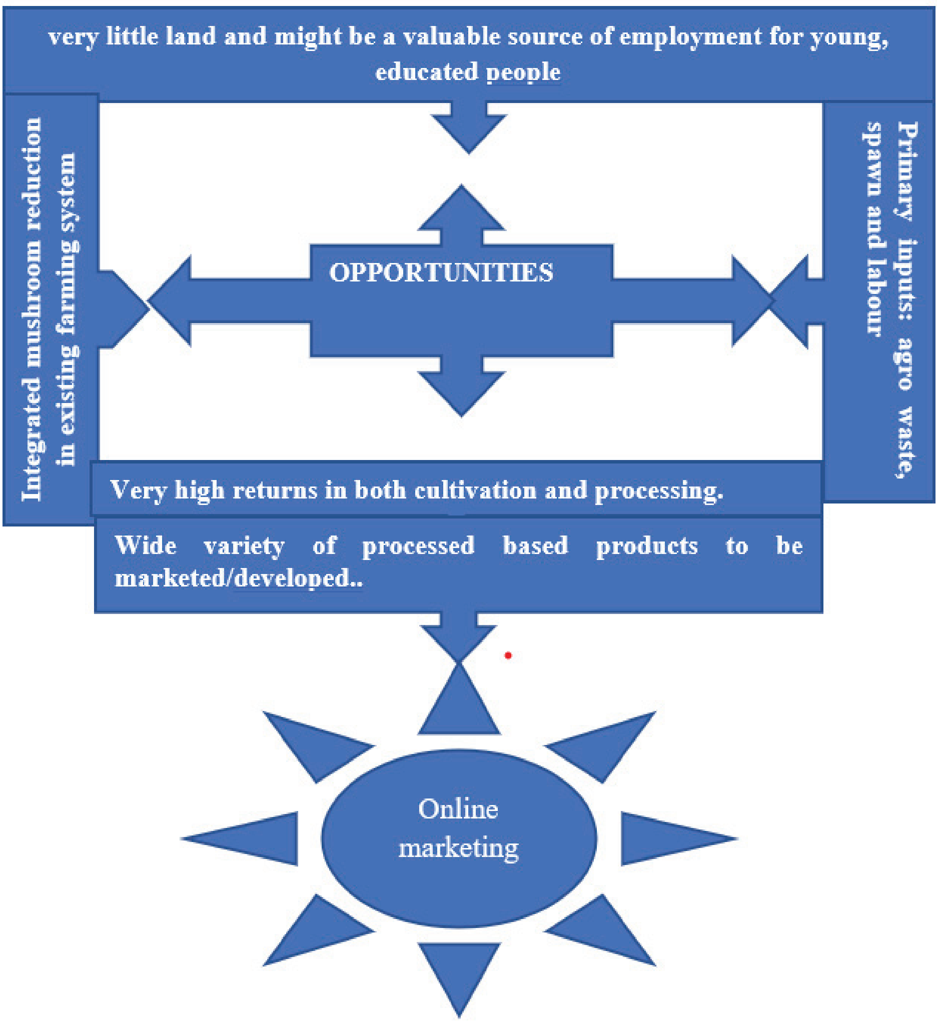
Threats: The marketing of mushrooms is a threat as we do have not a well-established market even for other crops. Competition from other counties and existing canned mushroom markets. Risk of supply exceeding demand. Sometimes different insect pests damage the mushroom crop.



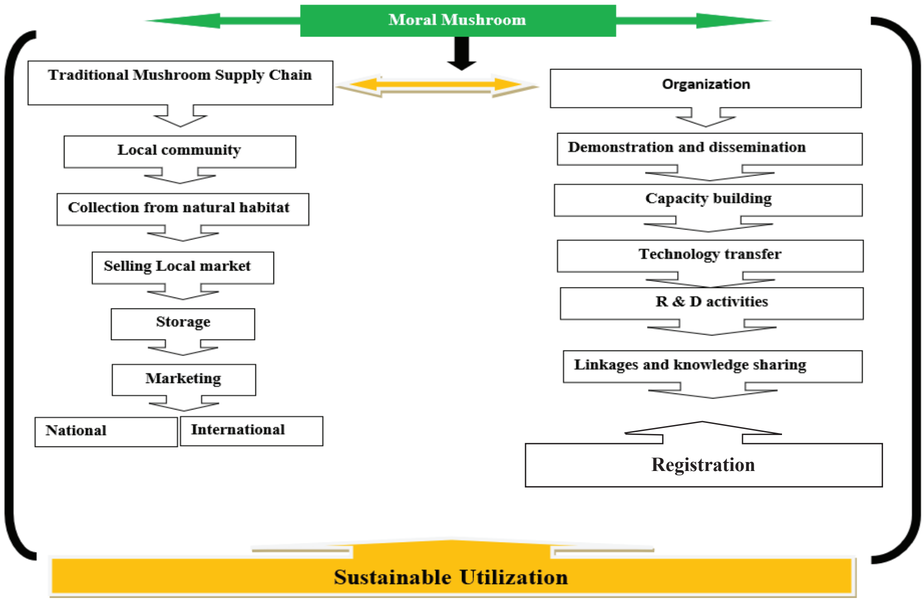
Marketing & Sales Plan

Financial Analysis

By supplying a high-yield, healthy food supply and a reliable source of income, mushroom farming can help end poverty and improve livelihoods. Since it doesn't require access to land, mushroom farming is a useful and alluring hobby for both semi-urban and rural residents. Mushroom farming has immense potential to provide new business avenues to uplift economy of the fragile communities and on the other hand it may support in improving nutrition, health, and food security situation. Morel value chain may involve many human resources in production, processing and marketing at local, regional, and national level providing jobs and money.



Entrepreneurship Opportunities



Conclusion

The current situation presents a significant challenge in ensuring the food and nutritional security of the world's expanding population. The farmer depends on crops, fruits, and vegetables. However, their production is decreasing daily due to different threats of the biotic and abiotic agents. In this situation, the cultivation of mushrooms finds a favor that can be grown even by landless people. There is a dire need for research on morels mushrooms which will help solve these problems and sustainable food and nutrition security. Morels are the most valuable culinary and medicinal mushrooms and have significant commercial and scientific importance. The distinctive springtime mushroom morels (Morchella spp.) are highly prized in food markets. The new developments regarding morel farming have ignited the hopes that this highly prized commodity will pave the way in the market and that promotion of the value chain will strengthen the commercial exploitation of morel mushrooms.

It is recommended that encourage people to grow Morel mushrooms as an alternative to traditional crops for sustainable development because they have great potential and economic return. There should be extensive campaigns to raise awareness of mushroom cultivation. And finally, Development of human resources is imperative for growing mushrooms and development of an efficient supply chain.

Suggested Citation

Hussain, A., Ali, S., Muhammad, F., Ali, A. (2023). Development of Moral Mushroom Technology in Gilgit-Baltistan: Chinese Experiences in Perspective, A Viable Option for Income Generation. In *Silk Route Revisited: Essays and Perspectives on the China-Pakistan Economic Corridor and Beyond* (pp.199-211). CSC-KIU.

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The establishment of centre aims to provide a base to learn not only Chinese society, but a window of opportunity to take advantage of this platform via developing research collaborations in Xinjiang and mainland China. These collaborations are key to conduct research with high relevance to GB. As referred above that, historically the GB (Pakistan) and Xinjiang (China) offer much in common to share, which includes languages, heritage sites, oral and documented traditions, religious traditions, socio-political and economic pacts, ethnography mapping of mountain communities, cultural diplomacy, etc. The commonalities of these wide range areas are significantly important to consider as an opportunity for collaboration between KIU, Chinese Universities and beyond.

Price: PKR1200/-

978-969-23900-1-9