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REVIEW ARTICLE

Scope and challenges of mushroom production and their mitigations in Nepal: A review

Rojina Sapkota[1*], Dipesh Joshi[1], Sujan Bogati[1] and Santoshi Malla[1]

[1]Institute of Agriculture and Animal Science, Tribhuvan University, NEPAL
[*]Corresponding author's E-mail: rozinasap@gmail.com

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ABSTRACT

This review paper aims to discuss and compile information regarding various scopes, challenges, and mitigating measures of mushroom cultivation in Nepal. Overall information on mushroom cultivation comprising its status, scope, and problems is vital for bringing positive change in this sector. Different secondary sources of information were reviewed and analyzed including journals like Elsevier and Springer. In Nepal, the production of mushrooms has increased about 8.23 times over a decade until 2020. Nepal is blessed with a range of ecosystems that really are ideal for mushroom production. Different mushroom species have been commercially cultivated in different parts of Nepal. Mushroom production can be used as an alternative source to overcome food and nutrition security problems and eventually leads to the livelihood improvement of people in developing countries like Nepal. The study revealed that mushrooms can be used to fight several diseases with their nutritional and medicinal properties. The demand for mushrooms is increasing nowadays more than ever. With the implementation of various measures with proper coordination and planning, mushroom cultivation can be proliferated. As a result, the mushroom industry has a lot of potentials to help the country's socioeconomic transition. Nepal can capitalize on this opportunity by enacting appropriate and concrete national mushroom policies and programs.

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INTRODUCTION

Mushroom, fruiting body of macrofungi both ascomycota and basidiomycota, constitute a momentary stage of reproduction in their life cycle (Das, 2010) they belong to the biological kingdom: Fungi (Pokhrel, 2016; Raut, 2019). The use of the word mushroom is varied based on place and time. In general, Mushrooms lack chlorophyll and hence are not able to prepare food for themselves. They manufacture food by using complex organic materials found in dead plant and animal tissue (Das 2010; Muritala and Lu, 2018; Venturella *et al*., 2021). Global consumption of mushrooms is high because of their organoleptic properties and is being used by humans for culinary purposes (Valverde, Hernández-Pérez, and Paredes-López 2015). Fresh mushroom production in Nepal was 1,530 mt in 2010/11 A.D., and it has expanded by about 8 times over the last decade (12,607 mt.) until 2019/20. Similarly, mushroom seed output in 2010/11 was 2,68,560 bottles per year, an increase of almost 6 times over a ten-year period to 15,99,435 bottles per year (MOALD, 2020). The use of mushrooms as nutritional as well as medicinal food is spreading around the globe (Kumar *et al*., 2022a,b,c. Various researches have been performed regarding the medicinal value of fungi (Halpern and Miller, 2002). Several types of research on its chemical composition have revealed its nutritional and medicinal character (Raut and Adhikari 2021). It is attracting a lot of healthy eaters with its low calorie, cholesterol and saturated fat properties (Barzee *et al*., 2021). Protein found in mushrooms is considered of higher quality as com-

pared to vegetables (Valverde *et al*., 2015). Rapid increment in health awareness and demand for meat substitutes have caused rapid surge in global mushroom consumption. Mushroom cultivation is one of the most economical and relatively short biological process in terms biotransformation of materials into pro-rich food (Chiu *et al*., 2000; Kumar *et al*., 2021a,b,c,d). At recent period, mushroom use has expanded up to a wider extent covering area of pharmaceuticals, nutraceuticals and cosmeceuticals industry. According to FAO data from 2004, there seems to be an increase in international interest in the usage of wild edible mushrooms. With an estimated yearly worth of more than USD 2 billion, a few species dominate the global market (Christensen *et al*., 2008). Although much more has to be learned about mushrooms, they serve an important role in boosting people's rural livelihoods in poor countries (Chen, 2004; FAO, 2004; Yun and Hall, 2004).

Methodology

Various sources of information were reviewed and analyzed. Different literatures and journals including Elsevier and Springer were also reviewed. Secondary source of data collection was done for this research.

Scope of mushroom farming in developing countries like Nepal

Initiation of mushroom cultivation was done by the Division of Plant Pathology, Nepal Agricultural Research Council (NARC) in the year 1974. Commercial cultivation of Oyster, Button, Shitake, Ganoderma and Straw mushrooms has been initiated in different parts of Nepal, which reflects rise in the economic status of Nepalese farmers. White button (*Agaricus bisporus*) and Oyster (*Pleurotus* spp.) mushrooms have dominated the local market to common consumers. Some fungi famous in Nepal include Shitake (*Lentinus edodes*) and Milky mushroom (Calocybe indica). In 1974, the entire output of mushrooms was barely 30 kg, but by 2016, it had increased to 9300 tonnes. According to the Nepal mushroom producers association, about 2750 rural households in Nepal are involved in mushroom production and economic activities (Raut, 2019). Artificial farming of button mushroom started in the year 1974 (Manandhar, 2004).

Several districts, including as Kathmandu, Bhaktapur, Lalitpur, Kaski, Parbat, Baglung, Dhankuta, Solukhumbu, Manang, Mustang, Nuwakot, Dhading, Myagdi, Palpa, Syangja, Tanahun, Gulmi, Lamjung, Gorkha, Bhojpur, and others, have commercial mushroom growing enterprises (Mishra and Mishra, 2017). Because of its ability to thrive in a wide temperature range with a variety of lingo-cellulose materials, oyster mushrooms are becoming more popular around the world. The discovery of bioactive compounds, including antitumor substances has led to interest in such mushrooms by industry, media, and the scientific community (Pokhrel, 2016). Mushroom production could be an alternative source to overcome problems related to food and nutrition security problems in some nations. livelihood improvement can be a plus point as the demand for mushroom is on rise due to increasing population, market expansions and changing of consumption behavior (Çelik and Peker, 2009).

The popularity of collecting and consuming wild edible mushroom in Nepal by various ethnic groups is still alive. Nepal is blessed with a range of ecosystems that really are ideal for mushroom production. Places such as Melamchi, Hele, Phulchoke, Sing Gompa, Ghorepani, etc. represent the best sites for Himalayan fungal flora proliferation (Mishra and Mishra, 2017). The diversified and wide climate range across the country has gifted a lot of varieties of mushrooms naturally (760 species) in Nepal and out of which around 170 species have been proven as edible mushrooms (Poudel and Bajracharya, 2017). According to Wang and Hall (2004), there is very high demand of wild edible mushrooms in the international market and it is still in rise. Nepal has the ability to produce those sought-after fungus species.

For the production of mushroom, various substrates play a prominent role in their growth and vitality. Straw mushroom thrives well in substrates like rice straw, cotton waste, banana leaves, etc. Various substrates materials which are commonly used for the mushroom production in Nepal are given in the table 1.

Nutritional purpose

Mushrooms are a luxury food product known for its unique texture upon biting and delicious flavour. Because of their bioactive contents, they have received much interest from culinary and pharmaceutical experts (Mariga *et al*., 2014; Sheu *et al*., 2007). Mushrooms were ingested in the early days of civilization primarily for their flavor and palatability. Because so much study has been undertaken on the chemical characteristics of mushrooms, it has been revealed that they can be utilised as a disease-fighting food, the recent use of mushrooms is completely different from the traditional use (Nallusamy, 2013). A man weighing 70 kg consume 100 to 200 g of mushrooms (dry weight) to maintain appropriate nutritional balance (Alam *et al*., 2008). The digestibility of mushroom protein has been observed to range

Table 1. Different materials used as substrate for different commercial mushroom species.

Mushroom Species	Materials used as substrate
Straw mushroom	Rice straw, Cotton waste, Banana leaves, Sugarcane trash, Wheat straw
Button mushroom	Wheat straw, compost
Shitake mushroom	pineapple crown and pineapple bracts, sugarcane foliage and bagasse , corn-cobs, sawdust from oak-wood trees, wheat straw
Oyster mushroom	Paddy straw, rice straw wheat straw, date-palm leaves empty fruit bunch, banana leaves, pine needles, sugarcane bagasse

(Niazi and Ghafoor, 2021)

from 72 to 83 percent (Goswami and Khariwal, 2020). Mushrooms have a nutritional value somewhere between meat and vegetables (Thatoi and Singdevsachan, 2014; Thakur, 2020). Mushroom have a high protein content (20–35%), are low in fats, and provide all 9 essential amino acids (Bellettini *et al*., 2019). According to Verma and Singh (1987), mushrooms are beneficial to vegetarians because they provide important amino acids found in animal proteins. Mushroom fruiting bodies are a high-protein food. Fresh mushrooms have a protein level ranging from 1.23 percent to 3.08 percent (Reis *et al*., 2012). The quantity of exogenous and endogenous amino acids, the percentage of individual exogenous amino acids (which should be similar to the proportion of body proteins), and the digestion of protein products influence the protein's quality. In mushrooms, carbohydrate is the most prevalent nutrient. Carbohydrate content in fresh fruiting bodies is around 6%, whereas carbohydrate content in dry fruiting bodies is over 53%. (Golak-Siwulska *et al*., 2018). Mushroom fruiting bodies contain a variety of vitamins, including B vitamins, vitamin D2, and trace amounts of vitamins A, E, & C (Orsine, 2013). Mushrooms are a great source of vitamins, particularly vitamin B (Wani *et al*., 2010). Eating mushrooms on a regular basis can help avoid vitamin D deficiency (Muszyńska *et al*., 2017). Mushroom fruiting bodies have a fat content of 0.14–0.90 percent. Free fatty acids, mono-, di-, and triglycerides, and sterols are the most common types of fat (Barros *et al*., 2008; Reis *et al*., 2012). Mushroom mycelium have such a large proportion of nutrients that are easily digested. K, P, Na, Ca, Mg, and Cu, Zn, Fe, Mo, and Cd are major mineral ingredients in mushrooms, while Cu, Zn, Fe, Mo, and Cd are minor constituents (Table 2) (Chang, 2009). Mushrooms diets have been recommended by the Food and Agricultural Organization (FAO) to help decrease malnutrition in developing nations where protein deficit has spread widely (Wani *et al*., 2010).

Medicinal use of mushroom

Medicinal mushrooms are the most valuable medicinal fungi that have yet to be commercially exploited. The bioactive substances that may be extracted from medicinal mushrooms help people's immune systems and improve their quality of life. Mushrooms have been used as medicine for a long time, but we were unaware of their full medicinal potential. The anti-tumor property of mushrooms and their metabolites is the most notable medical benefit that has piqued the public's interest. The mushrooms consisting of various exceptional nutritional and medicinal properties and those with antimicrobial compounds and bioactive metabolites with some probable pharmacological and therapeutic properties like anti-ulcer, sleep promoting, anti-aging, immunomodulation, anti-inflammatory, analgesic, chemo-preventive, anti-tumor, chemo and radio protective, anti-bacterial, anti-viral (including anti-HIV), hypo-lipidemic, hypoglycemic, anti-fibrotic, hepato-protective, anti-diabetic, anti-androgenic, anti-herpetic, anti-oxidative and radical-scavenging have been separated from various medicinal mushrooms (Venturella *et al*., 2021). The 'mushroom of immortality' is the Reishi mushroom (Alam *et al*., 2008)

Health-enhancing features of mushroom

Antioxidant activity: The high anti-oxidative potential of *A. bisporus*, which arises from the presence of phenolic compounds and ergothioneine, may protect the body from free radicals when consumed regularly. Because phenolic components, flavonoids, L-ascorbic acid, and carotenoids are lost during the thermal processing of mushrooms before ingestion, their anti-oxidative action is reduced by 45–79%. The losses were substantially larger when mushrooms were boiled. As a result, this operation is not advised (Jaworska *et al*., 2015).

Anticancer properties: Conjugated linoleic acid, which is contained in mushrooms, has been shown to inhibit cancer cell proliferation by preventing cancer cell reproduction, according to a study (Wang *et al*., 2021). Several extracts (polysaccharide-K, polysaccharide peptide, lentinan) are currently used as adjuvants to radiation and chemotherapy in Japan, Korea, and China

Table 2. The nutritional value of some of the most commonly grown mushroom species.

Nutritional Value (per 100gm) (raw)	Oyster mushroom (*P. ostreatus*)	Straw mushroom (*V. volvacea*)	Shitake mushroom (*L. edodes*)	White Button mushroom (*A. bisporus*)
Moisture (g)	89.18	90	89.74	92.82
Energy (kcal)	33	16	34	22
Protein (g)	3.31	2.4	2.24	2.11
Total fat (g)	0.41	0	0.49	0.35
Carbohydrate (g)	6.09	3.2	6.79	3.87
Fiber (g)	2.3	1.6	2.5	1.3
Sugars (g)	1.11	0	2.38	2.5
Calcium (mg)	3	8	2	3
Iron (mg)	1.33	0.14	0.41	0.31
Magnesium (mg)	18	8	20	9
Phosphorus (mg)	120	89	112	108
Manganese (mg)	0.113	0.05	0.23	0.069
Potassium (mg)	420	309	304	364
Sodium (mg)	18	7	9	9
Selenium (µg)	2.6	2.1	5.7	18.6
Vitamin D (µg)	0.7	0	0.4	0.3

(Niazi and Ghafoor, 2021)

(Sullivan *et al.*, 2006) *A. bisporus* extracts induced apoptosis in HL-60 leukaemic cells, inhibiting their growth (Jagadish *et al.*, 2009). MCF-7 breast cancer cells were inhibited by *A. bisporus* extracts had a much lesser impact on various cancers like, cancer of prostate gland, gastric carcinoma, and sarcoma 180 cell line cultures (Golak-Siwulska *et al.*, 2018).

Antimicrobial properties: Muszyńska *et al.* (2017) found that *A. bisporus* extracts were efficient against gram-positive bacteria such as *Micrococcus luteus*, *Micrococcus flavus*, *Bacillus subtilis*, and *Bacillus cereus*, as well as fungi such as *Candida albicans* and *Candida tropicalis*. Antimicrobial activity of the methanol *A. bisporus* extract was seen against *Escherichia coli*, *Proteus*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* bacteria, as well as *Aspergillus niger* fungi (Adams *et al.*, 2008).

Anti-inflammatory and analgesic properties: Fucogalactan, fucomannogalactan, and mannogalactan, all isolated from *A. bisporus* var. *hortensis* depicted the anti-inflammatory and anaesthetic properties in the research (Komura *et al.*, 2010).

Other advantages include: Mushrooms are great for preventing cardiovascular illnesses due to their high protein, sterols, macro-elements, and low calorie content (Muszyńska *et al.*, 2017b). Enhancement of macrophage function and host resistance to various bacterial, viral, fungal, and parasitic diseases, activation of non-specific immune stimulation, and lowering of blood cholesterol and glucose levels are all therapeutic qualities of mushrooms (Chiu *et al.*, 2000). *Lentinus edodus* has been utilized to boost vigor, sexuality, energy, and anti-aging properties (Jones and Lim, 1990).

Constraints and mitigation measures

The major constrains of mushroom production in Nepal is the lack of modern and latest technology and inadequate funding in scientific investigations of mushroom production. These problems can be addressed by acquiring relevant technology based on local needs and agro-climatic conditions furthermore, enough spending on research and development is also recommended respectively. Some of the Constraints of mushroom cultivations along with their respective mitigating measures are given in the table 3.

Table 3. Constraints and mitigation of Mushroom cultivation in Nepal.

Constraints	Mitigations
Lack of up-to-date technologies	Based on local needs and agro-climatic conditions, develop and acquire relevant technology.
Inadequate funding and scientific investigation into mushrooms.	R&D spending should be increased.
Increase the price of rice straw as a raw material	Diversify the raw substrate and look for alternatives using materials that are readily available in local area.
Spawn of poor quality	Establish a mushroom culture center, as well as spawn production centers that are technologically advanced. Ensure a steady supply of high-quality spawn at a minimal cost.
Pest invasion and poor agricultural management practices/diseases	Improving growers' on-farm cleanliness and integrated disease and pest control knowledge and skills.
Post-harvest Control	Cooperatives are formed. Improving knowledge and skills in the following areas: picking, grading, and preservation at the appropriate stage, cold storage, refrigerated transportation, suitable processing, appealing packaging, and labeling Establishing the mushroom value-added chain from farm to ultimate consumer
Promotional and marketing actions that aren't satisfactory	Popularizing mushrooms through ICT, including television, radio, advertisements, and posters, as well as mushroom festivals. Participation in national and international exhibitions Providing financial assistance to small and medium-sized businesses in particular
Farm-gate prices and profit margins are fluctuating.	Ensure year-round supply at a suitable standard rate by time-scheduling crops to achieve a daily relatively uniform output. promoting marketing, processing, and exporting through the private sector establishing a support price minimum Throughout the year, diversify and develop different mushrooms based on consumer preferences. For more profitable production, enhanced technology is being used to minimize the growing season and crop rotation lengths.
There aren't enough mushroom policies and rules	Develop and impose strict mushroom-related policies and legislation.
Competitors from the surrounding nations	Increasing additional investment in order to become more competitive Develop special policies for mushroom products in terms of trading, branding, and food safety.
Lack of a critical mass of well-trained mushroom technicians and producers to properly and successfully operate mushroom businesses	Managing and generating a sufficient number of well-trained and experienced human resources via well-equipped local mushroom resource centers
There is a lack of quality assurance and certification.	Creating distinct quality assurance and certification units to standardize products for the domestic and foreign markets.
Only foreign cultivars have been used in the farming system so far.	Collecting and cultivating locally accessible germplasm that is suitable for different agro-climatic situations.

Conclusion

The production of mushroom has increased by 8.23 times over a period of decade until 2020 AD in Nepal. Similarly, mushroom seed output was 2,68,560 bottles per year in 2010, an increase of almost 6 times over a ten-year period to 15,99,435 bottles per year until 2020. The mushroom business is progressively establishing itself in Nepal, although progress is slow due to a lack of scientific research and conservation. Growing mushroom for consumption and marketing in Nepal appears to be a practical and appealing option. Mushroom cultivation could possibly play a role in long-term agriculture and forestry. Mushrooms are an example of a component that not only makes use of vertical space but also aids in the production of high-quality food, as well as environmental sustainability and health. To fulfill the changing needs of food products, it is necessary to promote both mushroom production and consumption. As a result, the mushroom industry has a lot of potentials to help the country's socio-economic transition. Nepal can capitalize on this opportunity by enacting appropriate and concrete national mushroom policies and programs.

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REFERENCES

Adams, L. S., Chen, S., Phung, S., Wu, X., & Ki, L. (2008). White button mushroom (*Agaricus bisporus*) exhibits antiproliferative and proapoptotic properties and inhibits prostate tumor growth in athymic mice. *Nutrition and Cancer*, *60*(6), 744-756.

Alam, N., Amin, R., Khan, A., Ara, I., Shim, M. J., Lee, M. W., & Lee, T. S. (2008). Nutritional analysis of cultivated mushrooms in Bangladesh–*Pleurotus ostreatus*, *Pleurotus sajor-caju*, *Pleurotus florida* and *Calocybe indica*. *Mycobiology*, *36*(4), 228-232.

Barros, L., Cruz, T., Baptista, P., Estevinho, L. M., & Ferreira, I. C. (2008). Wild and commercial mushrooms as source of nutrients and nutraceuticals. *Food and Chemical Toxicology*, *46*(8), 2742-2747.

Barzee, T. J., Cao, L., Pan, Z., & Zhang, R. (2021). Fungi for future foods. *Journal of Future Foods*, *1*(1), 25-37.

Bellettini, M. B., Fiorda, F. A., Maieves, H. A., Teixeira, G. L., Ávila, S., Hornung, P. S., & Ribani, R. H. (2019). Factors affecting mushroom Pleurotus spp. Saudi *Journal of Biological Sciences*, *26*(4), 633-646.

Celik, Y., & Peker, K. (2009). Benefit/cost analysis of mushroom production for diversification of income in developing countries. *Bulgarian Journal of Agricultural Science*, *15*(3), 228-237.

Chang, S. T. (2009). "Overview of Mushroom Cultivation and Utilization as Functional Foods." Pp. 1–33 in Mushrooms as Functional Foods. John Wiley & Sons, Inc.

Chen, Y. (2004). Song rong (*Tricholoma matsutake*), a valuable mushroom from China: consumption, development and sustainability. In Forest products, livelihoods and conservation: case studies of NTFP systems (pp. 56-71). CIFOR.

Chiu, S. W., Law, S. C., Ching, M. L., Cheung, K. W., & Chen, M. J. (2000). Themes for mushroom exploitation in the 21st century: Sustainability, waste management, and conservation. *The Journal of General and Applied Microbiology*, *46* (6), 269-282.

Christensen, M., Bhattarai, S., Devkota, S., & Larsen, H. O. (2008). Collection and use of wild edible fungi in Nepal. *Economic Botany*, *62*(1), 12-23.

Das, K. (2010). Diversity and conservation of wild mushrooms in Sikkim with special reference to Barsey Rhododendron Sanctuary. NeBIO, *1*(2), 1-13.

FAO. (2004). "Wild Edible Fungi a Global Overview of Their Use and Importance to People." Retrieved February 2, 2022 (https://www.fao.org/publications/card/en/c/709ef43f-313d-5098-9178-d974989bfe72/).

Golak-Siwulska, I., Kałużewicz, A., Wdowienko, S., Dawidowicz, L., & Sobieralski, K. (2018). Nutritional value and health-promoting properties of (Lange) Imbach. *Herba Polonica*, *64*(4), 71-81.

Goswami, S., & Khariwal, S. (2020). "Cultivation of pleurotus species of mushroom, Its commercial products and study of Its biochemical properties." Retrieved February 2, 2022 (https://www.wjpps.com/Wjpps_controller/abstract_id/12862).

Halpern, G. M., & Miller. A. H. (2002). "Medicinal Mushrooms : Ancient Remedies for Modern Ailments." 172.

Thatoi, H., & Kumar S. S. (2014). "Diversity, Nutritional Composition and Medicinal Potential of Indian Mushrooms: A Review." *African Journal of Biotechnology* *13*(4), 523–545, https://doi.org/ 10.5897/ajb2013.13446

Jagadish, Loganathan K., V. Venkata Krishnan, R. Shenbhagaraman, & V. Kaviyarasan. 2009. "Comparitive Study on the Antioxidant, Anticancer and Antimicrobial Property of *Agaricus Bisporus* (J. E. Lange) Imbach before and after Boiling." *African Journal of Biotechnology* *8*(4), 654–61, https://doi.org/10.4314/ajb.v8i4.59906

Jaworska, G., Pogoń, K. Bernaś, E. & Duda-Chodak, A. (2015). "Nutraceuticals and Antioxidant Activity of Prepared for Consumption Commercial Mushrooms *Agaricus Bisporus* and *Pleurotus Ostreatus*." *Journal of Food Quality* 38(2), 111–22, https://doi.org/10.1111/JFQ.12132

Jones, E. B. Garet., and Lim, G. (1990). "Edible Mushrooms in Singapore and Other Southeast Asian Countries." *Mycologist* *4*(3), 119–24, https://doi.org/10.1016/S0269-915X(09)80038-4

Komura, Dirce L., Elaine R. Carbonero, Ana Helena P. Gracher, Cristiane H. Baggio, Cristina S. Freitas, Rodrigo Marcon, Adair R. S. Santos, Philip A. J. Gorin, and Marcello Iacomini. 2010. "Structure of *Agaricus Spp*. Fucogalactans and Their Anti-Inflammatory and Antinociceptive Properties." *Bioresource Technology* *101*(15), 6192–99, https://doi.org/ 10.1016/J.BIORTECH.2010.01.142

Kumar, P., Eid, E. M., Al-Huqail, A. A., Širić, I., Adelodun, B., Abou Fayssal, S., & Kumar, V. (2022a). Kinetic Studies on Delignification and Heavy Metals Uptake by Shiitake (*Lentinula edodes*) Mushroom Cultivated on Agro-Industrial Wastes. *Horticulturae*, *8*(4), https://doi.org/10.3390/horticulturae8040316

Kumar, P., Kumar, V., Adelodun, B., Bedeković, D., Kos, I., Širić, I., & Silva, L. F. (2022b). Sustainable Use of Sewage Sludge as a Casing Material for Button Mushroom (*Agaricus bisporus*) Cultivation: Experimental and Prediction Modeling Studies for Uptake of Metal Elements. *Journal of Fungi*, 8(2), https://doi.org/10.3390/jof8020112

Kumar, P., Kumar, V., Eid, E. M., AL-Huqail, A. A., Adelodun, B., Abou Fayssal, S., & Širić, I. (2022c). Spatial Assessment of Potentially Toxic Elements (PTE) Concentration in *Agaricus bisporus* Mushroom Collected from Local Vegetable Markets of Uttarakhand State, India. *Journal of Fungi*, *8*(5), https://doi.org/10.3390/jof8050452

Kumar, P., Kumar, V., Goala, M., Singh, J., & Kumar, P. (2021a). Integrated use of treated dairy wastewater and agro-residue for *Agaricus bisporus* mushroom cultivation: Experimental and kinetics studies. *Biocatalysis and Agricultural Biotechnology*, *32*, 101940, https://doi.org/10.1016/j.bcab.2021.101940

Kumar, V., Kumar, P., Singh, J., & Kumar, P. (2021b). Kinetics of nutrients remediation from sugar industry effluent-treated substrate using Agaricus bisporus: mushroom yield and biochemical potentials. *3 Biotech*, 11(4), 1-11, https://doi.org/10.1007/s13205-021-02712-z

Kumar, V., Kumar, P., Singh, J., & Kumar, P. (2021c). Use of sugar mill wastewater for *Agaricus bisporus* cultivation: prediction models for trace metal uptake and health risk assessment. *Environmental Science and Pollution Research*, 28 (21), 26923-26934, https://doi.org/10.1007/s11356-021-12488-7

Kumar, V., Valadez-Blanco, R., Kumar, P., Singh, J., & Kumar, P. (2020d). Effects of treated sugar mill effluent and rice straw on substrate properties under milky mushroom (*Calocybe indica* P&C) production: Nutrient utilization and growth kinetics studies. *Environmental Technology & Innovation*, 19, 101041, https://doi.org/10.1016/j.eti.2020.101041

Manandhar, L. Keshari. n.d. "Mushroom Cultivation to Make... - Google Scholar." *2004*. Retrieved February 2, 2022 (https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Manandhar+K.+L.+%282004%29+Mushroom+cultivation+to+make+living+in+Nepal.+Mushrooms+growers'+handbook+1.+Mushworld.+pp.+13–18.&btnG=)

Mariga, A. M., Yang, W., Mugambi, D. K., Pei, F., Li, Y. Zhao, Ya ni S., & Qiuhui H. (2014). "Antiproliferative and Immunostimulatory Activity of a Protein from Pleurotus Eryngii." *Journal of the Science of Food and Agriculture 94*(15), 3152–3162, https://doi.org/ 10.1002/jsfa.6665

Mishra, A. D., & Mishra, M. (2017). "Nutritional Value of Some Local Mushroom Species of Nepal." *Janapriya Journal of Interdisciplinary Studies 2*, 1–11, https://doi.org/10.3126/JJIS.V2I1.18060

MOALD. 2020. "Ministry of Agriculture and Livestock Development." *MOALD*. Retrieved February 5, 2022 (https://www.moald.gov.np/publication/Agriculture Statistics).

Mu, Ukwuru, A. Muritala, and Ezekiel Lu. 2018. "Edible and Non-Edible Wild Mushrooms: Nutrition, Toxicity and Strategies for Recognition." *Undefined*.

Muszyńska, B., Kała, K. Rojowski, J., Grzywacz, A., & Opoka, W. (2017a) "Composition and Biological Properties of Agaricus Bisporus Fruiting Bodies-a Review." *Polish Journal of Food and Nutrition Sciences 67*(3), 173–181, https://doi.org/10.1515/PJFNS-2016-0032

Muszyńska, B., Kała, K. Rojowski, J., Grzywacz, A., & Opoka, W. (2017b. "Composition and Biological Properties of Agaricus Bisporus Fruiting Bodies-a Review." *Polish Journal of Food and Nutrition Sciences 67*(3), 173–181, https://doi.org/10.1515/PJFNS-2016-0032

Niazi, A. R., & Ghafoor, A. (2021). "Different Ways to Exploit Mushrooms: A Review." *14*(1), 450–460. https://doi.org/10.1080/26895293.2021.1919570

Orsine, J. V. C. 2013. "Chemical Composition, Toxicity, Genotoxicity and Antigenotoxicity of the Mushroom *Agaricus Sylvaticus* Aiming at Food Safety (Sun Mushroom)." *Undefined*.

Pokhrel, C.P. (2016). "Cultivation of Oyster Mushroom: A Sustainable Approach of Rural Development in Nepal." *Journal of Institute of Science and Technology*, *21* (1), 56–60. https://doi.org/10.3126/JIST.V21I1.16050

Poudel, S., & Bajracharya, A. (2017). "Prospects and Challenges of Mushroom Cultivation in Nepal: A Case Study of Lakuri Bhanjyang, Lalitpur."

Raut, J. K. (2019). "Current Status, Challenges and Prospects of Mushroom Industry in Nepal." *4*(4), https://doi.org/ 10.11648/J.IJAE.20190404.13

Raut, J. K., & Adhikari, M. K. (2021). "Chapter 8 Mushroom: A True Super Food." Retrieved February 2, 2022 (https://www.researchgate.net/publication/353380594_Chapter_8_Mushroom_A_True_Super_Food).

Reis, Filipa S., Barros, L., Martins, A. ,& Isabel C. F. R. Ferreira. 2012. "Chemical Composition and Nutritional Value of the Most Widely Appreciated Cultivated Mushrooms: An Inter-Species Comparative Study." *Food and Chemical Toxicology: An International Journal Published for the British Industrial Biological Research Association 50*(2), 191–97. https://doi.org/10.1016/J.FCT.2011.10.056

Sheu, F., Chien, P. J., Wang, H. K., Chang, H. H. & Yuan T.S. (2007). "New Protein PCiP from Edible Golden Oyster Mushroom (*Pleurotus Citrinopileatus*) Activating Murine Macrophages and Splenocytes." *Journal of the Science of Food and Agriculture*, *87*(8),1550–1558, https://doi.org/10.1002/jsfa.2887

Nallusamy, S. (2013). "Nutritional and Medicinal Values of Mushrooms." Pp. 73–94 in *Food as Medicine*. En: Advances in horticulture. New Delhi, IN: Malhotra Publishing House, 1995. v. 13.

Sullivan, R., Smith, J. E. and Rowan. N. J. (2006). "Medicinal Mushrooms and Cancer Therapy: Translating a Traditional Practice into Western Medicine." *Perspectives in Biology and Medicine*, 49(2), 159–70, https://doi.org/ 10.1353/PBM.2006.0034

Thakur, M. P. (2020). "Advances in Mushroom Production: Key to Food, Nutritional and Employment Security: A Review." *Indian Phytopathology*, 73(3), 377–395.

Valverde, M. E., Hernández-Pérez, T., & Paredes-López, O. (2015). "Edible Mushrooms: Improving Human Health and Promoting Quality Life." *International Journal of Microbiology* 2015. https://doi.org/10.1155/2015/376387

Venturella, G., Valeria F., Cirlincione, F., & Gargano, M. L. (2021). "Medicinal Mushrooms: Bioactive Compounds, Use, and Clinical Trials." *International Journal of Molecular Sciences 22*(2), 1–31, https://doi.org/10.3390/IJMS22020634

Verma, R. N. & Singh, G. B. (1987). "Fleshy Fungal... - Google Scholar." Retrieved February 2, 2022 (https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Verma+RN%2C+Singh+GB%2C+Bilgrami+KS+%281987%29.+Fleshy+fungal+flora+of+N.+E.+H.+India-+I.+Manipur+and+Meghalaya.+Indian+Mush.+Sci.%2C+2%3A+414-+421&btnG=).

Wang, X., Desiree H., Hitomi M., & Chen. S. (2021). "White Button Mushroom (*Agaricus Bisporus*) Disrupts Androgen Receptor Signaling in Human Prostate Cancer Cells and Patient-Derived Xenograft." *The Journal of Nutritional Biochemistry*, 89, 108580, https://doi.org/10.1016/J.JNUTBIO.2020.108580

Wani, B. A., Bodha, R. H., & Wani, A. H. (2010). "Nutritional and Medicinal Importance of Mushrooms." *Journal of Medicinal Plants Research 4*(24), 2598–2604, https://doi.org/10.5897/JMPR09.565

Yun, W., & Hall, I. R. (2004). Edible ectomycorrhizal mushrooms: challenges and achievements. *Canadian Journal of Botany*, 82(8), 1063-1073, https://doi.org/10.1139/B04-051