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Turning Crop Residue into Food and Fertilizer: Oyster Mushroom (*Pleurotus ostreatus*) Cultivation as a Practical Response to Residue Burning and Winter Smog in Punjab, Pakistan

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ABSTRACT

Every winter, the plains of Punjab are covered by dense smog that closes schools, disrupts air and road transport, and increases respiratory illness. Vehicles, industry, brick kilns, and transboundary air masses all contribute, but open burning of crop residue is a seasonal and avoidable source. This article examines oyster mushroom cultivation as a low-cost way to turn agricultural residue into food, income, and organic soil amendment. It reviews the drivers of residue burning, the biology and nutritional value of *Pleurotus* species, a practical cultivation protocol suited to Punjab's winter climate, and the economic and environmental benefits. It also states the limits of the approach. Mushroom farming cannot absorb the full volume of residue produced in the province, but it can give farmers a profitable, proven alternative to burning, and it works well as an entry point to wider residue management.

1. Introduction

Each year, as temperatures fall across northern Pakistan and India, a grey haze settles over the cities and countryside of Punjab, from Lahore to Sargodha and from Faisalabad to Multan. It is not harmless winter mist. It irritates the eyes, damages the lungs, fills hospital emergency rooms with respiratory patients, and forces repeated closures of schools and delays to flights and motorways.

The causes are layered. Traffic emissions, industrial activity, brick kilns, and the burning of solid waste all add to the pollution load. Farm fields add another source. After harvest, farmers must clear straw and stubble quickly before the next crop, and with little time, labor, or affordable machinery, many choose fire. The smoke releases fine particulate matter (PM_{2.5} and PM₁₀), carbon monoxide, nitrogen oxides, and volatile organic compounds, which combine with urban and industrial emissions under

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the cold, still conditions of winter. Burning also removes organic matter and beneficial microorganisms from the topsoil, so the practice harms farmland as well as air quality.

The question explored here is whether the same residue could be put to productive use. Oyster mushrooms are among the easiest and cheapest cultivated fungi to grow, and they thrive on cereal straw. Used as a growing medium, straw becomes a source of protein-rich food and, afterward, a soil amendment. The cool, humid winters of Punjab, which coincide with the smog season, are also well suited to the crop.

2. The Problem: Residue Burning in the Rice-Wheat System

2.1. Scale

Punjab is the main grain-producing province of Pakistan and supplies most of the country's wheat and a large share of its rice. These crops leave behind very large quantities of straw each year. Pakistan as a whole is commonly estimated to generate tens of millions of tons of crop residue annually, with Punjab producing a major share.

Not all residue is burned. Wheat straw is widely chopped into *bhoosa* and used as animal fodder, and some residue serves as fuel or compost. Rice straw is the larger problem. It is coarse, high in silica, of low value as feed, and is produced in October and November, just before wheat sowing. This is why burning concentrates in the weeks that lead into the smog season. Any serious proposal for using residue should therefore treat rice straw and wheat straw differently, a point returned to in Section 6.

2.2. Why farmers burn

Blaming farmers overlooks the practical reasons behind the practice.

- **Time pressure.** The interval between rice harvest and wheat planting is often only two to three weeks.
- **Labor scarcity.** Manual collection and removal of straw is slow, and rural labor is increasingly costly.
- **Equipment cost.** Machines that incorporate or bale residue are beyond the reach of most small and medium farmers.
- **Perceived benefit.** Some farmers believe fire controls pests and disease and adds nutrients. Burning does release some potash in ash, but this is small compared with the nitrogen, sulfur, carbon, and microbial life lost.
- **Limited awareness.** Many growers do not link their own field fire to the urban smog that follows.

2.3. Health and economic consequences

Fine particles smaller than 2.5 micrometers reach deep into the lungs and enter the bloodstream. Exposure is linked to asthma, bronchitis, cardiovascular disease, and premature death. During winter, temperature inversions trap pollutants near the ground, and Lahore regularly appears among the most polluted cities in the world in air quality rankings. The costs include medical expenses, lost working days, school closures, and transport disruption, in addition to the loss of soil carbon and nitrogen on the burned fields themselves.

3. The Organism: Why Oyster Mushrooms

3.1. Biology

Oyster mushrooms belong to the genus *Pleurotus* and are named for their shell-like caps. They are saprotrophs, which means they feed on dead plant material. They produce enzymes, including laccases, peroxidases, and cellulases, that break down lignin and cellulose, the tough fibers that make straw hard to decompose. This allows them to grow on wheat straw, rice straw, cotton stalks, sugarcane bagasse, and many other residues with little or no supplementation. Their ability to use low-cost lignocellulosic waste is the main reason *Pleurotus* is among the most widely cultivated mushroom genera in the world (Sánchez, 2010).

Pleurotus ostreatus typically fruits at cool temperatures, which suits Punjab from roughly November to February. Related species such as *P. sajor-caju* (also marketed as *P. florida*) and *P. djamor* tolerate warmer conditions and can extend production into spring and autumn.

3.2. Nutritional value

Oyster mushrooms are valued as food as well as a crop. Published analyses report protein content in the range of about 20 to 30 percent of dry weight, depending on species, substrate, and growth stage, with a good spread of essential amino acids. They are low in fat, high in dietary fiber, and a source of B vitamins (riboflavin, niacin, and pantothenic acid), potassium, phosphorus,

iron, and zinc. Like all mushrooms, they contain ergosterol, which is converted to vitamin D₂ when the fruiting bodies are exposed to sunlight or ultraviolet light (Cheung, 2010).

They also contain beta-glucans and other bioactive compounds. Laboratory and some clinical studies report immune-modulating, cholesterol-lowering, antioxidant, and blood sugar-regulating effects. The evidence is promising but is still developing, and mushrooms should be described as a nutritious food rather than a medicine. For a population where protein and micronutrient deficiencies persist, a locally grown, inexpensive source of both has clear public health value.

4. Cultivation Protocol for Punjab Conditions

The following method is suited to small growers with a spare room or shed. It follows the standard bag-cultivation system described in the mushroom literature (Chang and Miles, 2004; Royse, Baars and Tan, 2017).

4.1. Substrate preparation

Use clean, dry, mold-free wheat straw. It is the most reliable substrate for beginners. Avoid straw from fields recently sprayed with herbicide or pesticide, because residues can suppress mycelial growth. Chop the straw into pieces of about 2 to 5 centimeters. This increases the surface area for colonization and makes packing easier.

Pasteurization is essential because straw carries competing molds and bacteria. For small operations, submerge the chopped straw in hot water held at roughly 65 to 80 degrees Celsius for 30 to 60 minutes, or steam it for a similar period. Chemical treatment with lime or a fungicide-bleach solution is used in some commercial systems but requires careful handling and rinsing, and it is not recommended for beginners.

After pasteurization, drain the straw until it is moist but not dripping. A simple field test is to squeeze a handful firmly: a few drops at most should appear between the fingers. This corresponds to a moisture content of about 65 to 70 percent. Let the straw cool fully to room temperature before adding spawn, because heat will kill the mycelium.

4.2. Spawning and bagging

Mix fresh, white spawn that is free of mold and has a clean mushroom smell evenly through the cooled straw at about 5 to 10 percent of the wet weight of substrate. Wash hands, clean the working surface, and avoid drafts during this step, since it is the point of greatest contamination risk. Pack the mixture firmly into clear polythene bags of 2 to 5 kilograms capacity. Tie the neck loosely enough to allow gas exchange, and make a number of small holes with a clean needle.

4.3. Incubation

Keep the bags in a dark or dim, clean room at about 20 to 25 degrees Celsius for two to three weeks. White mycelium should spread steadily until the entire block of straw is covered. Inspect the bags regularly. Green, black, or orange patches indicate contamination by competing molds such as *Trichoderma* or *Aspergillus*, and affected bags should be removed from the room immediately and kept away from the growing area.

4.4. Fruiting

When the bags are fully white, move them to a fruiting room with indirect light and good airflow. Hang them or place them on tiered racks, which can be built cheaply from bamboo or timber. Cut small X-shaped slits, about 3 to 5 centimeters, where pinheads begin to appear. Pins usually form within several days.

4.5. Humidity, air, and temperature

Maintain relative humidity at about 80 to 90 percent by misting the walls and floor once or twice a day rather than spraying the mushrooms directly. Provide enough ventilation to prevent carbon dioxide build-up, which causes long stalks and small, distorted caps, but avoid strong drafts that dry the crop. Fruiting is best at roughly 15 to 25 degrees Celsius, with *P. ostreatus* performing best toward the cooler end of that range.

4.6. Harvest and spent substrate

Harvest clusters when the cap margins are still slightly curled downward or flat, before they turn upward and begin dropping spores. Twist and pull the cluster gently from the base. A bag usually gives two to three flushes over several weeks, with the first flush the largest. After the last flush, the substrate is spent. This spent mushroom substrate (SMS) can be used as a soil conditioner or added to a compost heap, completing the cycle.

5. Benefits

5.1. Environmental

Every kilogram of straw used as substrate is a kilogram that is not burned. Open burning of cereal straw releases particulate matter, black carbon, carbon monoxide, methane, and nitrous oxide. Quantifying avoided emissions requires care, because published emission factors vary with fuel moisture, combustion conditions, and the pollutant considered, so any specific figure should be tied to a cited source and a stated method before it is used in policy discussion.

Spent substrate returns partly decomposed organic matter and fungal biomass to the soil. Studies of SMS and spent mushroom compost generally report improved soil structure, water retention, and nutrient supply, and some report reduced need for synthetic fertilizer. Results depend on the substrate, the application rate, and the soil type. Mushrooms are also a modest water user per unit of food produced, since they grow indoors without field evaporation.

5.2. Economic

Startup requirements are limited: a small room or shed, polythene bags, a drum or pot for pasteurization, spawn, a spray bottle, and simple racks. Reported biological efficiency (fresh mushroom weight per dry substrate weight) for oyster mushrooms on wheat straw commonly ranges from about 50 to 100 percent over a full crop, depending on strain and management. In practice, new growers often obtain less than this. The figure of 300 to 500 grams of fresh mushrooms per kilogram of dry straw is therefore realistic for a competent grower but should not be promised to a beginner.

Fresh oyster mushrooms in Pakistani urban markets have commonly sold within the range of several hundred rupees per kilogram, with prices varying by city, season, and buyer. A small room producing 20 to 50 kilograms a month could plausibly generate meaningful supplementary income, but net profit depends on spawn quality, contamination losses, labor, and above all reliable access to a buyer. Dried mushrooms, mushroom powder, and spawn production offer routes to higher margins and longer shelf life for experienced growers.

The activity also employs family labor, women in particular, because it can be carried out at home with limited capital. This makes it attractive for rural livelihood programs.

6. Limitations and Realistic Contribution

A fair assessment must state what mushroom cultivation cannot do.

First, the scale mismatch is large. A grower who harvests 50 kilograms of mushrooms in a month uses on the order of 100 to 150 kilograms of dry straw. Punjab's rice and wheat areas produce straw in the millions of tons. Even a very large expansion of mushroom farming would consume only a small fraction of this residue. Mushroom cultivation should be presented as one component of a package that includes baling for fodder and energy, biochar, composting, and machinery such as happy seeders for direct drilling into residue, not as a stand-alone cure for smog.

Second, rice straw is a harder substrate than wheat straw. It is higher in silica, less uniform, and often wetter at harvest. Wheat straw is easier to use, but it is also already in demand as animal feed. Farmers who burn rice straw in autumn may need to store and use it with wheat straw or other supplements, and the timing of winter mushroom production must be matched to the availability of dry straw.

Third, the market is limited. Mushroom consumption in Pakistan is still small, and fresh product has a short shelf life. If many new growers sell into the same local market at the same time, prices will fall. Cold chain, drying, and market development need to grow in step with production.

Fourth, technical risk is real. Contamination, poor spawn, and temperature extremes cause losses, especially for beginners. Quality spawn supply in Pakistan is uneven, and growers need access to reliable laboratories and training.

Fifth, outside winter, *P. ostreatus* needs cooling. Summer production requires warm-tolerant species or climate control, which raises costs.

7. Recommendations

- Treat mushroom farming as one part of an integrated residue strategy, and set realistic targets for the quantity of residue it can absorb.
- Expand agricultural extension training through provincial departments, universities, and NGOs, with emphasis on hygiene, pasteurization, and record keeping.

- Support certified spawn production at district level so that growers have access to fresh, tested cultures at fair prices.
- Develop markets through drying, packaging, and links to restaurants and retailers, so that new supply does not collapse local prices.
- Fund field trials in Punjab that measure yield, profit, contamination rates, and the effect of spent substrate on soil and crops, so that local evidence replaces borrowed figures.
- Pair training with incentives such as small grants or microcredit tied to not burning residue, and monitor outcomes using satellite fire detection and farm surveys.

8. Conclusion

Smog in Punjab results from many interacting sources, and no single practice will remove it. Residue burning is, however, one of the more controllable ones, and the farmers who burn do so largely because they lack workable alternatives. Oyster mushroom cultivation converts a disposal problem into a product, using simple equipment and the natural cool season of the region. It supplies protein, creates household income, and yields an organic soil amendment. Its direct effect on regional air quality will be modest unless it is combined with other residue management options, but as a demonstration of circular agriculture it is practical, teachable, and already proven. The strongest case for it is as a starting point for farmers to see standing straw as a resource, which is a change in thinking that larger solutions will also depend on.

References

- Chang, S.T. and Miles, P.G. (2004). *Mushrooms: Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact*, 2nd edition. CRC Press, Boca Raton.
- Cheung, P.C.K. (2010). The nutritional and health benefits of mushrooms. *Nutrition Bulletin*, 35(4), 292-299.
- Royse, D.J., Baars, J. and Tan, Q. (2017). Current overview of mushroom production in the world. In: Diego, C.Z. and Pardo-Giménez, A. (eds), *Edible and Medicinal Mushrooms: Technology and Applications*. Wiley-Blackwell.
- Sánchez, C. (2010). Cultivation of *Pleurotus ostreatus* and other edible mushrooms. *Applied Microbiology and Biotechnology*, 85(5), 1321-1337.