# Globalisation and the Rise of Mushroom Cultivation: Opportunities, Challenges, and Changing Consumption Patterns in a Connected World

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**Abstract**

Mushroom cultivation has moved from a collection of geographically bounded food traditions to a rapidly expanding and increasingly integrated global industry. This article examines how globalisation has accelerated the diffusion of cultivation knowledge, spawn technologies, controlled-environment systems, processing methods, culinary practices and international trade, while simultaneously creating new vulnerabilities related to market concentration, perishability, biosecurity, regulatory fragmentation and unequal participation in value chains. The paper adopts a structured narrative review of peer-reviewed literature, official agricultural and trade statistics, food-safety assessments and supply-chain studies. Available evidence indicates that reported world production of mushrooms and truffles has increased dramatically since the 1960s, with China accounting for a dominant share of recorded output and for a substantial proportion of international trade in dried products. Growth has also been supported by urbanisation, rising incomes, demand for convenient and functional foods, interest in low-meat diets, and the ability of many cultivated fungi to convert lignocellulosic residues into edible biomass. These features create opportunities for rural enterprise, women and youth employment, diversification of farm income, circular bioeconomy applications, value-added processing and diet improvement. However, mushrooms are highly perishable; yields are sensitive to temperature, humidity, hygiene and spawn quality; controlled production may be energy intensive; and unverified health claims can outpace clinical evidence. Consumption patterns are changing from localised use of a few traditional species towards wider acceptance of shiitake, oyster, enoki, wood ear and other specialty mushrooms, as well as powders, extracts, snacks, blended meat products and fortified foods. The paper argues that the benefits of globalisation will not be automatic. Inclusive growth requires decentralised quality spawn systems, producer organisations, cold chains, transparent standards, responsible health communication, life-cycle-based sustainability assessment and policies that enable small producers to retain value. A balanced global mushroom economy should connect international knowledge and markets with locally adapted substrates, species, cuisines and institutions.

**Keywords:** globalisation; edible mushrooms; mushroom cultivation; global value chains; circular bioeconomy; consumer behaviour; functional foods; sustainable agriculture.

## 1. Introduction

Globalisation has reorganised food systems by intensifying cross-border flows of commodities, capital, technologies, information, tastes and regulatory models. In agriculture, its influence is visible not only in the trade of staple crops but also in the rapid internationalisation of specialised foods that were formerly associated with particular

ecologies and culinary cultures. Cultivated mushrooms provide a particularly instructive case. Shiitake was historically embedded in East Asian food and medicinal traditions; button mushrooms became closely associated with European and North American commercial horticulture; oyster mushrooms were cultivated in many regions as adaptable decomposers of agricultural residues; and wood ear, enoki, paddy-straw and milky mushrooms developed within distinctive regional production and consumption systems. These boundaries are increasingly porous. Supermarkets, restaurant chains, e-commerce, migration, tourism and food media now place multiple mushroom species before consumers who may have had little previous familiarity with them.

The industry has expanded at a remarkable pace. Royse, Baars and Tan (2017) reported that world production of cultivated edible mushrooms had increased more than thirty-fold since 1978 and that five genera—Lentinula, Pleurotus, Auricularia, Agaricus and Flammulina—accounted for most global supply. FAOSTAT data similarly show a very large long-term rise in reported production of the broad statistical category “mushrooms and truffles”, from less than half a million tonnes in 1961 to more than 48 million tonnes in 2022 (FAO, 2024). These data should be interpreted cautiously because national reporting systems, commodity definitions and the inclusion of different production forms are not fully comparable. Nevertheless, the direction of change is unambiguous: mushrooms have shifted from a relatively limited speciality sector to a significant component of the global horticultural, food-processing and nutraceutical economy.

This transformation reflects more than increased output. Globalisation has changed what is cultivated, how it is cultivated, where value is created and how mushrooms are understood by consumers. Standardised spawn, improved strains, substrate formulation, climate-controlled houses, modified-atmosphere packaging, drying, canning, freezing and high-pressure processing have extended production seasons and market reach (Sangeeta et al., 2024). At the same time, digital platforms circulate cultivation tutorials, recipes and health narratives across borders at unprecedented speed. Global value chains link sawdust, straw and other substrates; laboratories producing cultures and spawn; farms; processors; exporters; wholesalers; retailers; restaurants; supplement companies and online marketplaces. These linkages can create livelihoods and encourage innovation, but they can also concentrate power and expose producers to volatile input costs, strict quality requirements and uneven bargaining relationships.

The purpose of this paper is to analyse the rise of mushroom cultivation through the lens of globalisation. It addresses three questions: first, through which mechanisms has globalisation stimulated production and market expansion? Second, what economic, social, nutritional and environmental opportunities have emerged, and what constraints accompany them? Third, how are consumption patterns changing as mushrooms move across cultural, technological and commercial boundaries? The article focuses primarily on edible cultivated mushrooms while recognising that medicinal products, wild-harvested mushrooms and mycelium-based materials increasingly overlap with the food economy.

## 2. Materials and Methods

The paper uses a structured narrative review design. Literature was identified from peer-reviewed journal articles, academic books, official reports and international statistical databases dealing with mushroom production, nutrition, processing, consumer acceptance, sustainability, trade, food safety, rural enterprise and global value chains. Priority was given to sources with transparent methods, peer review or institutional authority, including FAOSTAT, World Bank trade data, the European Food Safety Authority and studies indexed

in major scientific databases. Seminal works on mushroom cultivation and global production were combined with recent research on processing, circular economy applications, novel-food acceptance and environmental life-cycle assessment.

The evidence was organised thematically rather than pooled statistically because the available literature is heterogeneous in species, production system, geographic scale, functional unit and consumer population. Production statistics often aggregate mushrooms and truffles, whereas scientific studies distinguish species and cultivation systems. Market studies frequently use proprietary definitions, and environmental assessments vary in system boundaries and energy mixes. Consequently, quantitative figures are used to illustrate tendencies rather than to produce a single global estimate of profitability, health impact or environmental performance. The analytical framework combines global value-chain reasoning with food-systems and circular-economy perspectives (Gereffi, Humphrey and Sturgeon, 2005; FAO, 2018; Grimm and Wösten, 2018).

## 3. Globalisation as a Driver of Mushroom-Sector Expansion

### 3.1 Diffusion of biological knowledge and cultivation technology

Commercial mushroom production depends on biological control rather than conventional field cultivation. Producers must manage fungal genetics, spawn quality, substrate composition, sterilisation or pasteurisation, temperature, humidity, carbon dioxide, light, hygiene and harvest timing. The global circulation of this technical knowledge has been fundamental to sector growth. Early cultivation systems were often species- and place-specific, such as log cultivation of shiitake or manure-based composting for Agaricus. Research institutes, universities, multinational spawn companies, development agencies and private consultants have translated such systems into standard operating procedures that can be adapted to diverse climates and resource bases.

Oyster mushrooms illustrate the importance of technological adaptability. Pleurotus species colonise a wide range of lignocellulosic materials, including cereal straw, cotton waste, maize residues, sawdust, sugarcane bagasse and other agro-industrial by-products. Their relatively rapid growth and broad temperature tolerance have made them suitable for both small enterprises and industrial production (Sánchez, 2010; Raman et al., 2020). Knowledge transfer has allowed farmers in regions without a long commercial mushroom tradition to begin production with locally available materials. Conversely, industrial systems have adopted automation, sensor-based environmental control and centralised substrate preparation to standardise yields and reduce biological risk.

Globalisation has therefore operated through two partly contrasting pathways. One is a low-capital pathway based on locally sourced residues, manual labour and short supply chains. The other is an industrial pathway based on proprietary strains, climate control, mechanised filling and harvesting, data monitoring, branded inputs and regional or international distribution. Both pathways benefit from international knowledge flows, but their access to finance, certification, cold storage and market intelligence differs substantially.

### 3.2 Trade, logistics and the separation of production from consumption

Fresh mushrooms contain high moisture and remain biologically active after harvest, making them vulnerable to browning, water loss, microbial spoilage and textural deterioration. Historically, this perishability restricted consumption to producing regions. Processing and logistics have weakened that constraint. Canning created durable international markets for button mushrooms; drying enabled shiitake, wood ear and other species to travel long distances; freezing and improved packaging widened institutional and retail use; and modern cold chains permit fresh mushrooms to move across national borders within tightly managed

time windows. Recent processing research includes modified-atmosphere packaging, high-pressure processing, intelligent quality assessment, spectroscopy and non-destructive monitoring (Sangeeta et al., 2024).

Trade data demonstrate the importance of shelf-stable forms. In 2023, China was by far the largest recorded exporter of dried mushrooms and truffles, shipping more than 57 million kg with a trade value close to US$897 million under the relevant customs category (World Bank, 2024). Dried products reduce transport weight, extend shelf life and allow mushrooms to enter retail, food-service and ingredient markets far from production centres. At the same time, the economics of fresh trade favour geographically compact chains, rapid transport or production close to major cities. This helps explain the coexistence of large export clusters with expanding urban and peri-urban farms.

**3.3 Culinary globalisation and the circulation of taste**

Demand has risen because culinary cultures are increasingly interconnected. Migration carries recipes and ingredient preferences; restaurants introduce consumers to unfamiliar species; cooking programmes and social media normalise new textures and flavours; and multinational retailers stock ingredients used in multiple cuisines. Shiitake, enoki and wood ear are no longer confined to East Asian markets, while button and portobello mushrooms are widely incorporated into Asian, African and Latin American food-service systems. Oyster mushrooms have become a bridge product because they can be grown locally yet used in stir-fries, curries, soups, snacks and meat-like preparations.

Mushrooms possess strong umami characteristics arising from free amino acids and nucleotides. This allows them to enhance savoury intensity and partially replace meat in mixed dishes. In a consumer study involving beef–mushroom formulations, Guinard et al. (2016) found that mushroom-containing taco blends could achieve acceptance comparable with all-beef formulations for substantial consumer segments, while also supporting sodium reduction. Such findings connect mushroom demand to the global search for dietary strategies that reduce red-meat intake without requiring abrupt changes in familiar foods.

**3.4 Health, wellness and the functional-food economy**

Mushrooms are commonly valued for low energy density, low fat, dietary fibre, potassium, B vitamins and bioactive constituents, although composition varies by species, substrate, maturity and processing (Kalač, 2013; Valverde, Hernández-Pérez and Paredes-López, 2015). Ergosterol in mushrooms can be converted to vitamin D2 through ultraviolet exposure, creating opportunities for fortified foods and powders (Cardwell et al., 2018). Beta-glucans, ergothioneine, phenolic compounds and other components have generated scientific and commercial interest. However, evidence supporting specific therapeutic outcomes remains uneven, and food-level benefits should not be confused with claims made for concentrated extracts (Roupas et al., 2012; Feeney et al., 2014).

The global wellness economy has nevertheless transformed mushrooms into ingredients for coffee substitutes, beverages, snack bars, capsules, powders and “adaptogenic” blends. E-commerce has accelerated this trend by allowing small brands to market internationally without conventional retail networks. The result is a widening gap between ordinary culinary mushrooms and premium functional products. That gap can create value, but it also raises questions about species authentication, dosage, extraction methods, safety, evidence and permissible health claims. Regulatory decisions such as the European assessment of ultraviolet-treated vitamin D2 mushroom powder show that innovation increasingly requires formal safety evaluation and compositional standardisation (EFSA NDA Panel, 2024).

## 4. Opportunities Created by the Global Rise of Mushroom Cultivation

### 4.1 Rural livelihoods, entrepreneurship and employment

Mushroom farming can generate income from relatively small physical areas and can be integrated with existing crop, livestock and agro-processing systems. Production cycles are shorter than those of many tree or field crops, enabling more frequent cash flow. Activities such as substrate preparation, bag filling, pasteurisation, inoculation, crop management, harvesting, grading, drying and marketing create labour demand. Entry-level oyster production can use simple rooms and locally fabricated equipment, whereas more advanced enterprises create jobs in laboratory culture, spawn production, engineering, refrigeration, packaging, quality assurance and logistics.

These characteristics are particularly relevant for land-constrained households, women, young entrepreneurs and peri-urban producers. FAO guidance has long presented small-scale mushroom production as a diversification option that can convert residues into saleable food (Marshall and Nair, 2009). Yet livelihood outcomes depend on reliable spawn, technical support and market access. Training programmes that promote production without simultaneously developing demand, aggregation and cold-chain systems can create gluts and farmer losses. The opportunity is therefore not mushroom cultivation in isolation, but coordinated enterprise development across the chain.

### 4.2 Circular bioeconomy and agricultural-residue utilisation

Many mushroom-forming fungi can transform low-value lignocellulosic materials into edible products. This is one of the strongest arguments for their inclusion in circular food systems. Straw, sawdust, husks, stalks, cotton waste and other residues can become substrate rather than being burned, dumped or left to decay unmanaged. Pleurotus cultivation is particularly flexible in this respect (Raman et al., 2020). After cropping, spent mushroom substrate retains partially degraded organic matter, fungal biomass and nutrients.

Spent substrate may be composted, applied as a soil amendment, used as a component of growing media, incorporated into animal-feed research, subjected to further fungal cultivation, converted to bioenergy, or used in biobased materials. Grimm and Wösten (2018) argue that mushroom systems can support circularity by linking food production with compost, enzymes, energy and materials. However, circularity is not achieved merely because a residue is used once. The safety and economic viability of substrate sourcing, transport, treatment and final application must be assessed. Contaminated feedstocks, excessive salts, plastic bags and long-distance transport can offset anticipated benefits.

### 4.3 Farm diversification and climate adaptation

Mushrooms can diversify farm income and reduce dependence on a single commodity. Since cultivation occurs indoors or under shelter, production can be partly insulated from drought, hail and direct solar stress. Species selection allows adaptation to different temperature ranges: button mushrooms favour cooler controlled environments, while paddy-straw, milky and some oyster mushrooms can be produced under warmer conditions. Diversification is especially useful where climate variability undermines predictable field-crop income.

Nevertheless, indoor production is not independent of climate. Heat waves can raise cooling costs and contamination risk; irregular electricity can compromise environmental control; and extreme humidity can affect disease. Climate adaptation therefore requires low-energy house design, insulation, evaporative cooling where appropriate, heat-tolerant strains, water management and locally calibrated production calendars. Global breeding knowledge must be combined with local climatic experimentation rather than copied without adaptation.

### 4.4 Value addition, market segmentation and export potential

The diversity of mushroom species and product forms creates multiple market segments. Producers can sell fresh whole mushrooms, sliced products, dried pieces, powders, pickles, sauces, soups, seasoning blends, ready-to-cook products, snack foods and ingredients for bakery, dairy, meat and plant-based formulations. Processing reduces dependence on the narrow fresh-market window and permits the use of cosmetically imperfect but safe mushrooms. It can also increase unit value and allow branding around origin, species, cultivation method or nutritional characteristics.

Supply-chain research in Italy shows that firms differentiate through species diversity, retail channels, processing and certification, but that the sector also faces fragmented structures and a need for stronger coordination (De Cianni, Varese and Mancuso, 2023). Similar principles apply elsewhere. Producer groups can pool volumes, negotiate packaging and transport, share drying or cold-storage facilities, and meet retailer specifications. Digital commerce can connect niche farms with restaurants and households, although online marketing does not eliminate the need for reliable fulfilment and food-safety systems.

### 4.5 Nutrition and dietary diversification

Mushrooms can contribute sensory diversity and selected micronutrients to diets dominated by refined staples. They are not nutritionally equivalent to meat on a fresh-weight basis because their protein density is generally much lower, but they can complement legumes, cereals, vegetables, eggs or modest quantities of animal foods. Their savoury taste may help improve acceptance of lower-meat and lower-sodium meals. Ultraviolet-exposed mushrooms can also provide vitamin D2, subject to validated processing and labelling (Cardwell et al., 2018; EFSA NDA Panel, 2024).

The most realistic public-health role is therefore as part of diversified dietary patterns rather than as a miracle food. Nutrition programmes should distinguish between whole edible mushrooms, fortified mushroom foods and concentrated supplements. Claims should reflect the form and quantity actually consumed. This distinction is crucial in a global marketplace where health narratives can travel faster than scientific consensus.

## 5. Challenges and Risks in an Integrated Global Industry

### 5.1 Concentration of production and unequal value distribution

Reported global production is highly concentrated, with China accounting for the overwhelming majority of FAOSTAT-recorded output in recent years. Concentration can generate economies of scale, specialised clusters, research capacity and export competitiveness. It can also create dependence on a limited number of supply regions and make comparison difficult when statistical methods differ. Within countries, industrial growers may dominate supermarket contracts because they can guarantee year-round volume, standard size, traceability and packaging. Small farms may be confined to informal or volatile markets.

Global value-chain analysis emphasises that participation does not guarantee equitable returns. Lead firms may control standards, branding, processing, data and access to consumers, while growers bear biological and price risks (Gereffi, Humphrey and Sturgeon, 2005). Inclusive development requires institutions that improve producers' bargaining power, enable collective marketing, and prevent contracts from transferring disproportionate risk to farms.

### 5.2 Biological risk, spawn quality and disease management

Mushroom cultivation is vulnerable to competing moulds, bacteria, viruses, flies and mites. Small errors in moisture, temperature, hygiene or pasteurisation can cause total crop failure.

Poor-quality or mislabelled spawn reduces yield and undermines farmer confidence. As strains and substrate materials move across borders, biosecurity becomes more important. Informal transfer of cultures may spread pathogens or introduce poorly adapted genetic material.

Quality-assured spawn laboratories, diagnostic capacity and extension services are therefore public goods as well as commercial inputs. Certification should verify identity, purity, vigour and production date without imposing costs that exclude small suppliers. Training must emphasise contamination prevention, record keeping and safe disposal rather than presenting cultivation as a simple "waste-to-food" activity.

**5.3 Perishability, cold chains and post-harvest loss**

Perishability is among the most persistent barriers to profitable expansion. Fresh mushrooms can lose quality within days, especially under warm conditions. A rapid increase in production without demand forecasting, cooling and processing can depress prices and generate waste. Industrial firms use vacuum cooling, refrigerated storage, controlled atmospheres, retail packaging and just-in-time logistics, but these systems require capital and stable electricity. Small producers often harvest into uncertain markets and may lack even basic insulated transport.

Processing technologies can extend shelf life, yet they alter colour, texture, aroma and nutrient retention and may require regulatory approval. Drying is accessible but energy use and product hygiene need attention. Canning is durable but capital- and water-intensive. Modified-atmosphere packaging reduces deterioration only when combined with temperature control. Technology choice should therefore reflect market distance, consumer preference, energy availability and scale rather than global fashion alone (Sangeeta et al., 2024).

**5.4 Environmental trade-offs**

Mushrooms are often described as inherently sustainable because they can use residues and require little arable land. This claim is directionally plausible but incomplete. Environmental performance varies with substrate, yield, energy source, house design, packaging, transport, peat or casing materials, water treatment and spent-substrate management. A cradle-to-gate assessment of Agaricus bisporus production in Spain estimated 4.42 kg CO2-equivalent per kg of mushrooms and identified climate control as a major impact source (Leiva et al., 2015). A study of a circular urban farm found approximately 2.99–3.18 kg CO2-equivalent per kg of fresh mushrooms, with energy and transport remaining important despite the use of urban organic residues (Dorr et al., 2021).

These findings do not imply that mushrooms perform poorly relative to all foods; rather, they show that sustainability cannot be inferred from substrate reuse alone. Comparative claims must use consistent functional units and consider nutrient density, loss rates and product form. Renewable energy, high biological efficiency, local substrate sourcing, reusable containers, alternatives to single-use plastic bags and productive use of spent substrate can improve performance. Conversely, low yields in heavily climate-controlled rooms may erase some circular-economy advantages.

**5.5 Food safety, authenticity and responsible claims**

Cultivated mushrooms can accumulate elements present in substrates, water or casing materials, while wild mushrooms may accumulate metals or be confused with toxic species. International trade makes traceability and species authentication more important. Producers need tested substrates, hygienic water, residue controls and accurate labels. Processed

powders and extracts are especially difficult for consumers to identify visually, increasing the importance of documented supply chains and analytical verification.

Health communication is another challenge. Traditional use and laboratory findings may justify research but do not automatically establish clinical efficacy in humans. The scientific literature identifies promising bioactive compounds, yet many proposed benefits remain based on in vitro, animal or small human studies (Roupas et al., 2012; Feeney et al., 2014). Global online marketing can detach claims from dose, species and preparation. Regulators and industry bodies should distinguish general nutrition statements from authorised health claims and should require the scientific name, fungal material used, extraction method and standardised constituents where relevant.

### 5.6 Cultural acceptance, affordability and market volatility

Global exposure does not produce uniform acceptance. Some consumers associate mushrooms with desirable taste, health and sustainability; others dislike their texture, fear poisoning, or regard unfamiliar species with suspicion. A systematic review of novel-food acceptance found that familiarity, knowledge, sensory properties, perceived healthiness, sustainability and food neophobia all influence adoption (Laureati et al., 2024). Information can raise expectations but cannot compensate for poor taste or texture.

Recent work on plant- and mushroom-based jerky illustrates this tension. Chaffee and Ardoin (2025) found that product concepts generated moderate expectations, but blind tasting revealed texture and liking limitations, and consumers were sensitive to protein information and price. This has a broader implication: mushrooms may contribute to meat alternatives, but products should not imply nutritional equivalence where protein content differs substantially. Successful innovation requires sensory testing, transparent labelling and prices that consumers can sustain beyond novelty purchases.

## 6. Changing Consumption Patterns in a Connected World

### 6.1 From a narrow species base to culinary diversification

For much of the twentieth century, commercial mushroom consumption in many Western countries was dominated by Agaricus bisporus sold as white button, crimini or portobello. Globalisation has broadened availability. Shiitake, oyster, enoki, king oyster, shimeji, wood ear and maitake now appear in mainstream retail and restaurant channels in numerous countries. In parallel, regions with strong traditions of Asian mushrooms have adopted Western-style pizzas, burgers, sauces and canned button mushrooms. The outcome is not cultural homogenisation but hybridisation: species and recipes are recombined in new contexts.

The rise of specialty mushrooms also reflects changing retail aesthetics. Distinct colours, shapes and textures enable premium positioning and visual marketing. Chef interest and social media reward unusual species, while controlled-environment farms can supply consistent quality. However, a proliferation of novelty varieties may coexist with limited household knowledge about storage and cooking, producing waste or one-time purchases. Culinary education remains an important demand-side intervention.

### 6.2 From fresh produce to ingredients and processed foods

Consumption is increasingly mediated by processing. Dried shiitake and wood ear have long been traded internationally, but contemporary forms include mushroom powders, seasoning mixes, soup concentrates, noodles, bakery products, chips, jerky, sauces, beverages and fortified foods. Processing enables mushrooms to enter products in which the fruiting body is not visually recognisable. This expands demand beyond households that cook fresh mushrooms and provides an outlet for lower-grade produce.

The ingredient pathway also changes competition. A fresh farm may compete locally on quality and service, whereas a powder supplier competes on standardisation, microbial safety, particle size, flavour intensity, bioactive content and price. International buyers may require third-party certification and continuous documentation. As value shifts towards formulation, branding and intellectual property, primary producers risk receiving a smaller share unless they participate in processing or cooperative marketing.

**6.3 Mushrooms in flexitarian and reduced-meat diets**

Mushrooms occupy a distinctive position in the transition towards lower-meat diets. They are not plants, yet they fit easily into plant-forward meal patterns. Their texture and umami make them suitable for "blend" strategies in burgers, sauces, dumplings and minced dishes. Blending can be more culturally acceptable than complete substitution because it preserves familiar flavours while reducing meat quantity. Evidence from sensory trials supports the feasibility of such approaches for some dishes and consumer segments (Guinard et al., 2016).

At the same time, mushroom-based analogues face nutritional and sensory constraints. Fresh mushrooms are mostly water and generally provide less protein per serving than meat or concentrated legume products. Product development often combines mushrooms with soy, peas, wheat gluten or other proteins. Consumer acceptance depends on texture, cooking behaviour, ingredient familiarity, price and truthful communication. The most defensible role for mushrooms may be as flavour- and texture-rich components within diversified formulations rather than as a universal standalone meat replacement.

**6.4 Premiumisation and the functional-mushroom trend**

A second consumption trajectory is premiumisation. Lion's mane, reishi, cordyceps and related fungi are marketed in powders, extracts, coffee blends, beverages and supplements. Global online retail has brought ingredients from traditional medicinal systems into wellness markets, often using narratives of cognition, immunity, energy or stress adaptation. This creates demand for specialised cultivation and extraction, but it can blur the boundary between food and medicine.

The trend is likely to continue because it aligns with consumer interest in natural, functional and personalised products. Its legitimacy, however, will depend on better human research, quality standards and surveillance. Species names alone are insufficient: fruiting bodies and mycelium may have different compositions; growing media can remain in mycelium-based powders; and extraction conditions influence measured compounds. The connected world increases both access to innovation and exposure to exaggerated claims.

**6.5 Convenience, food service and digital purchasing**

Urban lifestyles encourage convenient formats such as pre-sliced mushrooms, meal kits, ready sauces, frozen mixes and restaurant dishes. Food-service demand can stabilise volumes and introduce consumers to new species, but it also imposes strict requirements for uniformity, delivery schedules and food safety. Online grocery and direct-to-consumer subscriptions support local farms and premium varieties, especially in metropolitan areas. Digital platforms also allow farms to communicate recipes, harvest dates and production methods, increasing trust and reducing consumers' uncertainty.

Nevertheless, digital visibility can intensify competition and create dependence on platform fees, ratings and rapid fulfilment. Farms that appear "local" to consumers may rely on imported cultures, equipment or packaging. This is a reminder that local and global are not opposites: contemporary mushroom businesses often combine local production with global knowledge, inputs and culinary influences.

## 7. Discussion

The global mushroom boom illustrates the dual character of food-system globalisation. On one side, international connectivity spreads useful biological knowledge, expands dietary diversity, creates markets for agricultural residues, and allows producers to learn from cultivation systems developed elsewhere. It enables a farmer to access a tested strain, a processor to use improved preservation methods, a chef to adopt a foreign species, and a consumer to encounter new flavours. These flows can support entrepreneurship, resource efficiency and nutrition.

On the other side, connectivity can amplify concentration, biological risk, speculative health narratives and unequal value capture. The same standardisation that enables supermarket supply can exclude growers unable to meet volume and documentation requirements. The same cold chains that widen availability can increase energy use. The same functional-food discourse that attracts investment can encourage claims stronger than the evidence. The same online tutorials that democratise knowledge can understate contamination risk or promote unsuitable technologies.

A key analytical conclusion is that mushroom cultivation should not be treated as a single technology. The environmental and social consequences of a low-energy oyster unit using local straw differ from those of an industrial button-mushroom complex with year-round refrigeration, imported casing inputs and long-distance distribution. Likewise, a cooperative producing dried culinary mushrooms differs from a branded supplement company selling imported extracts. Policy must therefore be species-specific, product-specific and chain-specific.

A second conclusion concerns scale. Small producers have comparative advantages in local freshness, specialty species, cultural knowledge and flexible customer relationships. Large producers have advantages in climate control, laboratory capacity, processing, quality systems and retail contracts. Rather than assuming one optimal scale, development strategies should create links between them. Decentralised farms can be supported by regional spawn laboratories, shared substrate-treatment centres, cooperative cold rooms, mobile processing units, digital demand forecasts and transparent procurement contracts.

A third conclusion is that consumption growth depends on culinary usefulness more than abstract health messaging. Consumers repeatedly purchase foods that are tasty, affordable, convenient and familiar enough to fit everyday meals. Health and sustainability attributes can strengthen demand, but they rarely compensate for poor texture, uncertainty or high price. The internationalisation of mushroom cuisine has succeeded where species are embedded in practical recipes and accessible product formats.

## 8. Policy and Industry Recommendations

First, governments and research institutions should strengthen decentralised spawn and diagnostic systems. Public–private laboratories can maintain verified cultures, test strains under local conditions and train technicians. Minimum quality standards should protect farmers from contaminated or weak spawn while avoiding unnecessary barriers to local enterprises.

Second, enterprise programmes should be market-led. Before expanding production, planners should assess household demand, restaurant requirements, seasonal price patterns, competing supply and processing options. Training packages should include costing, hygiene, bookkeeping, packaging, customer development and crop-failure management rather than cultivation alone.

Third, shared infrastructure should be prioritised where individual investment is uneconomic. Collection centres, vacuum or forced-air cooling, refrigerated transport, solar or hybrid dryers, quality laboratories and common packaging facilities can reduce loss and improve bargaining power. Producer organisations can coordinate planting cycles and avoid simultaneous market gluts.

Fourth, circular-economy claims should be supported by material-flow and life-cycle evidence. Policies can encourage locally available, uncontaminated substrates; alternatives to peat where agronomically feasible; renewable energy; reusable crates; plastic reduction; and safe markets for spent substrate. Environmental certification should reward measured improvement rather than relying on the assumption that all mushroom production is low impact.

Fifth, food-safety and authenticity systems must evolve with processing and e-commerce. Labels should use accepted scientific and common names, identify the relevant fungal material, and disclose fortification or extraction where appropriate. Traceability should extend to substrate, spawn and processing. Cross-border standards should facilitate legitimate trade while preventing unsubstantiated therapeutic claims.

Sixth, demand development should focus on culinary literacy. Public institutions, chefs, extension services and retailers can demonstrate affordable recipes, storage practices and preparation methods for locally cultivable species. School and community food programmes may trial mushroom-containing dishes where supply, acceptability, safety and cost are carefully evaluated. Nutrition communication should present mushrooms as one component of dietary diversity, not as a substitute for balanced diets or medical care.

Finally, small producers should be enabled to retain more value through collective brands, geographical identity, direct sales, species differentiation and local processing. Digital platforms can support these aims, but producer data and customer relationships should not be controlled exclusively by intermediaries.

**9. Priorities for Future Research**

Future research should improve the comparability of global statistics by distinguishing cultivated species, fresh and dry weight, fruiting-body and mycelium products, and wild versus cultivated output. Production concentration and trade dependence cannot be assessed accurately when categories are too broad. More open, species-level data would also support disease surveillance and investment planning.

Environmental studies should compare representative production systems using harmonised boundaries and should report energy, water, substrate origin, biological efficiency, packaging, transport and end use of spent substrate. Research is needed on low-energy climate control, peat alternatives, biodegradable or reusable cultivation containers, and safe cascading uses of substrate.

Socio-economic research should examine who gains from sector expansion. Longitudinal studies are needed on household income, women’s control of earnings, youth employment, contract fairness, business survival and the distribution of value among spawn suppliers, farms, processors and retailers. Claims that mushroom projects alleviate poverty should be tested against failure rates and opportunity costs.

Consumer research should move beyond stated interest to repeated purchasing and real-world meal use. Cross-cultural studies can identify how species familiarity, texture, price, environmental information and health claims interact. Product developers should evaluate nutritional composition and sensory acceptance together, particularly for mushroom-based meat alternatives and functional beverages.

Finally, clinical and food-science research should clearly distinguish whole mushrooms from extracts, species from species, and fruiting bodies from mycelium. Better characterisation, dose reporting and independently replicated human trials are essential for credible health communication.

**10. Conclusion**

Globalisation has been central to the rise of mushroom cultivation. It has connected traditional knowledge with modern biotechnology, local residues with distant markets, regional cuisines with global consumers, and farm production with processing, wellness and materials industries. These connections have expanded the species cultivated, the places in which they are produced and the forms in which they are consumed.

The sector offers substantial opportunities. Mushrooms can diversify income, generate employment, utilise lignocellulosic residues, enrich food cultures and support lower-meat culinary strategies. Processing and digital marketing can reduce geographic isolation and create higher-value products. Yet these opportunities are accompanied by fragile biology, perishability, energy demands, uneven market power, regulatory complexity and the danger of exaggerated health claims.

The future of the global mushroom economy should therefore be judged not only by production volume or market growth, but by how value, risk and environmental responsibility are distributed. A resilient strategy will combine global science and trade with local species selection, substrates, enterprise networks and cuisines. It will support small producers without romanticising low-technology systems, encourage industrial efficiency without ignoring energy and waste, and promote nutritional value without overstating medical effects. Under these conditions, mushroom cultivation can become a meaningful component of inclusive, diversified and circular food systems in a connected world.

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