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Determinants of Mushroom Production in Ethiopia: A Review

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ABSTRACT

This review investigates the factors shaping mushroom production in Ethiopia, focusing on agro-climatic, socio-economic, technological and institutional influences. Agro-climatic factors like climate, soil and geography are critical in determining suitable cultivation areas. Socio-economic aspects, including market demand, labor and financial resources, significantly affect the scale and success of mushroom farming. Technological advancements in cultivation methods, training and research are vital for improving productivity and quality. Institutional and policy frameworks, including government support and land tenure, play a key role in enabling sector growth. The review suggests recommendations for enhancing mushroom production through improved policies, better institutional support and increased research investment. It also identifies future research needs in strain development, substrate use, market opportunities and policy effectiveness. This review aims to provide insights for advancing the sustainable development of Ethiopia's mushroom industry.

Key words: Climate, Determinants, Mushroom, Policy, Research.

Mushroom production in Ethiopia has seen a steady increase in recent years, driven by the growing recognition of its economic, nutritional and environmental benefits (Gebremariam and Tesfaye, 2021). Traditionally, mushrooms were not widely consumed in Ethiopia, with their use largely confined to certain communities; however, this trend has shifted as awareness of their health benefits has spread, particularly in urban areas like Addis Ababa (Alemayehu, 2019). The country's diverse agro-ecological zones, which range from highlands to lowlands, provide suitable conditions for the cultivation of various mushroom species, including both edible and medicinal types (Muluneh, 2018).

One of the key determinants of mushroom production in Ethiopia is the availability of suitable substrates, which are critical for the growth and yield of mushrooms (Tesfaye, 2021). Agricultural by-products such as straw, sawdust and coffee husks are abundant in Ethiopia and can be effectively utilized as substrates, reducing production costs and promoting environmental sustainability (Dawit and Ketema, 2020). However, the lack of widespread knowledge and technical expertise among farmers poses a significant barrier to the efficient use of these resources (Melaku, 2017).

The Ethiopian government has recognized the potential of mushroom farming as part of its broader strategy to diversify agricultural production and improve food security (Ethiopian Ministry of Agriculture, 2022). In recent years, the government has launched several initiatives aimed at promoting mushroom cultivation, including the establishment of spawn production centers and the provision of training programs for farmers (Kebede, 2020). These efforts are complemented by the work of non-governmental organizations (NGOs) and international development agencies, which have been instrumental in providing technical support and facilitating market access for smallholder mushroom farmers (Alemu, 2019).

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Despite these efforts, several challenges continue to hinder the growth of the mushroom industry in Ethiopia. Among these are limited access to high-quality spawn, inadequate infrastructure for production and marketing and a general lack of awareness about the economic potential of mushroom farming (Mulugeta and Bekele, 2019). Addressing these challenges requires a coordinated approach that includes research and development to improve mushroom varieties, extension services to disseminate best practices and policies that support the commercialization of mushroom farming (Tekle, 2021).

Furthermore, the integration of mushroom farming into existing agricultural systems presents significant opportunities for enhancing rural livelihoods and promoting sustainable agricultural practices (Gebremariam and Tesfaye, 2021). By making use of agricultural waste and requiring relatively low capital investment, mushroom farming can be an attractive option for smallholder farmers looking to diversify their income sources (Fekadu, 2022). Therefore, this review aims to identify the key determinants of mushroom production in Ethiopia, provide recommendations for enhancing the sector and highlight future research needs for sustainable development.

This review on mushroom production in Ethiopia, conducted at Mekdela Amba University from 2023 to 2024, utilized a systematic approach, conducting extensive searches across academic databases and institutional reports with keywords related to "mushroom production" and "determinants". Emphasis was placed on recent studies and reports from the past decade, incorporating both peer-reviewed articles and gray literature from government and NGOs. Data were meticulously categorized by key factors agro-climatic, socio-economic, technological and institutional-focusing on variables such as climate, soil quality, market demand and policies.

Major determinants of mushroom production

Agro-climatic factors

Climate

The climate is a crucial determinant of mushroom production, as mushrooms require specific temperature and humidity levels for optimal growth. Ethiopia's diverse climate, characterized by variations in temperature, rainfall and humidity, creates both opportunities and challenges for mushroom cultivation (Muluneh, 2018). The ideal temperature range for most edible mushrooms, such as oyster and button mushrooms is between 20°C and 30°C, with a relative humidity of 70% to 90% (Chong *et al.*, 2023). Ethiopia's highland areas, such as those in the regions of Amhara and Oromia, offer favorable conditions for mushroom farming, with moderate temperatures and consistent rainfall that support year-round production (Gebremariam and Tesfaye, 2021).

However, in the lowland areas, where temperatures can exceed 30°C, mushroom production becomes more challenging due to the heat stress on the fungal spores (Fekadu, 2022). In these regions, controlled environment cultivation, such as using shade nets or greenhouses, becomes necessary to regulate temperature and humidity levels (Dawit and Ketema, 2020). Additionally, the bimodal rainfall pattern in Ethiopia, characterized by the main rainy season (Kiremt) from June to September and the short rainy season (Belg) from March to May, affects the availability of water for mushroom cultivation (Mulugeta and Bekele, 2019). Adequate water supply is essential for maintaining the high humidity required for mushroom growth, making irrigation systems critical in areas with irregular rainfall (Gebremariam and Tesfaye, 2021).

The effects of climate change, including increased temperatures and unpredictable rainfall patterns, pose additional risks to mushroom production in Ethiopia (Assefa, 2020). Changes in climate can lead to shifts in the suitable agro-ecological zones for mushroom cultivation, potentially reducing the areas where mushrooms can be grown effectively (Melaku, 2017). Adaptation strategies, such as the development of heat-tolerant mushroom strains and the use of climate-resilient agricultural practices, are needed to mitigate these impacts (Tekle, 2021).

Soil

Soil quality is another critical factor influencing mushroom production. Although mushrooms are typically grown on organic substrates rather than soil, the quality of the soil indirectly affects the availability of these substrates (Gebremariam and Tesfaye, 2021). Ethiopia's soils are highly diverse, ranging from fertile volcanic soils in the highlands to less fertile, sandy soils in the lowlands (Muluneh, 2018). The availability of agricultural by-products, such as straw, sawdust and coffee husks, which are commonly used as substrates for mushroom cultivation, is closely linked to the type of crops grown and the overall soil fertility (Dawit and Ketema, 2020).

In regions with rich agricultural activities, such as the Ethiopian highlands, the abundance of organic matter in the soil supports the production of high-quality substrates for mushroom farming (Desisa *et al.*, 2023). These substrates are essential for providing the necessary nutrients for the growth of mushrooms, particularly nitrogen, carbon and other minerals (Fekadu, 2022). On the other hand, in areas with poor soil fertility, the availability of suitable substrates may be limited, thereby constraining mushroom production (Gebremariam and Tesfaye, 2021).

Moreover, the pH of the substrate is a critical factor that influences mushroom yield. Most mushrooms prefer a slightly acidic to neutral pH, ranging from 5.5 to 7.0, for optimal growth (Assefa, 2020). The pH of the substrate can be influenced by the soil from which the organic matter is derived, making soil management practices, such as liming or composting, important for maintaining suitable conditions for mushroom cultivation (Mulugeta and Bekele, 2019). In Ethiopia, the use of composted agricultural waste, enriched with additional nutrients, has been shown to improve substrate quality and enhance mushroom yields (Tekle, 2021).

Geographical distribution

The geographical distribution of mushroom production in Ethiopia is largely determined by the availability of suitable climatic and soil conditions (Gebremariam and Tesfaye, 2021). The highland regions, particularly in areas above 1,500 meters above sea level, are the most conducive for mushroom farming due to their cooler temperatures, higher humidity and fertile soils (Muluneh, 2018). These regions include parts of the Amhara, Oromia and Southern Nations, Nationalities and Peoples' (SNNP) regions, where smallholder farmers and commercial enterprises have established mushroom farms (Gizaw *et al.*, 2018).

In contrast, the lowland areas, which are typically hotter and drier, are less favorable for mushroom production unless modified environments are employed (Fekadu, 2022). In these regions, the reliance on irrigation and temperature control technologies increases the cost of production, making mushroom farming less economically viable for smallholder farmers (Assefa, 2020). However, in some lowland areas, such as the Rift Valley, where access

to irrigation is available, mushroom cultivation is still practiced, though on a smaller scale compared to the highlands (Gebremariam and Tesfaye, 2021).

The distribution of mushroom farms also reflects the proximity to major urban markets, particularly Addis Ababa, where demand for mushrooms is highest (Dawit and Ketema, 2020). The central and northern highlands, which are closer to these urban centers, have seen more rapid growth in mushroom production due to better market access and infrastructure (Mulugeta and Bekele, 2019). This geographical distribution highlights the importance of both agro-climatic conditions and market dynamics in determining the success of mushroom production in Ethiopia (Tekle, 2021).

Socio-economic factors

Market demand

Market demand plays a critical role in determining the scale and success of mushroom production in Ethiopia. In recent years, there has been a noticeable increase in the demand for mushrooms, particularly in urban areas like Addis Ababa, where consumers are becoming more health-conscious and seeking nutritious food alternatives (Alemayehu, 2019). This growing demand is driven by the recognition of mushrooms as a rich source of protein, vitamins and minerals, which are increasingly valued in the diets of urban populations (Melaku, 2017). The expanding middle class and the rise in disposable income in urban areas have further fueled the demand for mushrooms, making it a lucrative crop for farmers (Fekadu, 2022).

However, the market for mushrooms in Ethiopia remains underdeveloped compared to other agricultural products, with limited supply chains and market linkages (Dawit and Ketema, 2020). Most mushroom farmers in Ethiopia face challenges in accessing reliable markets due to inadequate infrastructure, lack of cold storage facilities and limited knowledge of market dynamics (Mulugeta and Bekele, 2019). These challenges are exacerbated by the perishable nature of mushrooms, which require efficient handling and timely marketing to prevent spoilage (Gebremariam and Tesfaye, 2021). As a result, many farmers are unable to fully capitalize on the growing market demand, leading to fluctuations in supply and pricing (Assefa, 2020).

Moreover, the lack of awareness among rural consumers about the nutritional and medicinal benefits of mushrooms has limited the expansion of the market beyond urban centers (Alemu, 2019). To address these challenges, there is a need for greater investment in market development, including the establishment of cooperatives, improvement of market infrastructure and promotion of mushroom consumption through awareness campaigns (Tekle, 2021). These efforts would help stabilize the market, reduce post-harvest losses and increase the profitability of mushroom farming in Ethiopia (Fekadu, 2022).

Labor

Labor availability is another crucial factor influencing mushroom production in Ethiopia. Mushroom cultivation is labor-intensive, particularly during the substrate preparation, spawning and harvesting stages, which require skilled labor to ensure high yields and quality (Gebru *et al*., 2024). In many parts of Ethiopia, particularly in rural areas, there is an abundant supply of labor due to high levels of unemployment and underemployment (Dawit and Ketema, 2020). This labor pool provides an opportunity for smallholder farmers to engage in mushroom farming as a means of livelihood diversification and income generation (Mulugeta and Bekele, 2019).

However, the availability of skilled labor for mushroom production is limited, as many farmers lack the necessary training and expertise in mushroom cultivation techniques (Gebremariam and Tesfaye, 2021). The technical nature of mushroom farming, which involves maintaining specific environmental conditions and preventing contamination, requires a level of knowledge and skill that is not commonly found among traditional farmers (Fekadu, 2022). Training programs and extension services are therefore essential to equip farmers with the skills needed to manage mushroom farms effectively (Tekle, 2021).

In addition to technical skills, labor productivity in mushroom farming is influenced by the social dynamics within farming communities. In many Ethiopian rural areas, farming activities are often carried out collectively by family members or community groups (Melaku, 2017). This collective approach can be beneficial for labor-intensive tasks like substrate preparation and harvesting, but it may also lead to challenges in labor management and coordination (Alemayehu, 2019). Ensuring that all participants are adequately trained and motivated is key to maintaining high productivity and quality in mushroom production (Gebru *et al*., 2024).

Financial resources

Access to financial resources is a significant determinant of the scale and success of mushroom production in Ethiopia. Mushroom farming requires an initial investment in infrastructure, such as spawn production units, substrate preparation facilities and climate control systems, which can be costly for smallholder farmers (Gebremariam and Tesfaye, 2021). In Ethiopia, many farmers face challenges in accessing credit due to the underdeveloped financial sector, lack of collateral and high interest rates (Mulugeta and Bekele, 2019). This financial constraint limits the ability of farmers to invest in necessary equipment and technologies that could enhance their productivity and profitability (Fekadu, 2022).

Moreover, the seasonal nature of mushroom production and the associated cash flow fluctuations pose additional financial risks for farmers (Dawit and Ketema, 2020). Without sufficient financial reserves or access to credit, farmers may struggle to cover operating costs during

periods of low production or market downturns (Alemayehu, 2019). This financial vulnerability is particularly pronounced among smallholder farmers, who often lack the resources to absorb shocks and invest in innovations that could improve their production efficiency (Assefa, 2020).

To address these financial barriers, there is a need for tailored financial products and services that cater specifically to the needs of mushroom farmers (Tekle, 2021). Microfinance institutions, cooperatives and government programs can play a crucial role in providing accessible and affordable credit to farmers, enabling them to invest in mushroom production and scale their operations (Alemu, 2019). Additionally, financial literacy programs can help farmers better manage their finances, plan for the long term and reduce their vulnerability to financial shocks (Gebremariam and Tesfaye, 2021).

Technological factors

Cultivation techniques

The success of mushroom production in Ethiopia is heavily influenced by the cultivation techniques employed by farmers. Traditional methods of mushroom cultivation, which often rely on low-cost, locally available materials, are still widely practiced across the country (Gebremariam and Tesfaye, 2021). These methods include the use of agricultural by-products such as straw, coffee husks and sawdust as substrates, which are readily available and cost-effective (Alemayehu, 2019). However, traditional techniques often result in lower yields and quality due to suboptimal conditions, such as inadequate moisture levels, poor ventilation and high contamination rates (Dawit and Ketema, 2020).

To improve productivity and quality, modern cultivation techniques have been introduced, including the use of improved substrates, pasteurization and controlled environment systems (Mulugeta and Bekele, 2019). These advanced techniques allow for better control over the growing environment, including temperature, humidity and light, which are critical for the successful cultivation of mushrooms (Kavaliauskas *et al.*, 2022). For instance, the introduction of climate-controlled mushroom houses has enabled farmers in Ethiopia to produce mushrooms year-round, rather than being limited by seasonal variations (Fekadu, 2022). Moreover, the use of high-quality spawn, produced under sterile conditions, has significantly reduced contamination risks and increased yields (Tekle, 2021).

Despite these advancements, the adoption of modern cultivation techniques remains limited among smallholder farmers due to the high initial investment costs and lack of technical knowledge (Gebremariam and Tesfaye, 2021). Many farmers continue to rely on traditional methods, which are less efficient and more prone to crop failure (Assefa, 2020). Expanding the adoption of modern techniques requires targeted interventions, such as subsidies for equipment and inputs, as well as increased access to credit (Alemayehu, 2019). Additionally, farmer-to-farmer knowledge exchange and demonstration plots have proven effective in promoting the adoption of improved practices (Mulugeta and Bekele, 2019).

Training and extension services

Training and extension services are crucial for building the technical capacity of mushroom farmers in Ethiopia. Given the specialized nature of mushroom cultivation, farmers require knowledge and skills that go beyond traditional crop farming practices (Dawit and Ketema, 2020). Training programs that cover the entire production cycle from substrate preparation to harvesting and post-harvest handling are essential for ensuring high yields and product quality (Gebremariam and Tesfaye, 2021). These programs are typically delivered by agricultural extension agents, NGOs and private sector actors, who provide both theoretical knowledge and practical demonstrations (Melaku, 2017).

However, the coverage and effectiveness of training and extension services in Ethiopia are uneven, with many rural areas lacking access to these critical resources (Alemu, 2019). In regions where extension services are available, the quality of training can vary, depending on the expertise of the trainers and the resources allocated to the programs (Fekadu, 2022). Furthermore, the integration of mushroom cultivation into existing agricultural extension services is still in its early stages and many extension workers lack the specialized knowledge needed to support mushroom farmers effectively (Gatdet, 2022).

To address these challenges, there is a need for a more coordinated approach to training and extension services, involving partnerships between government agencies, research institutions and the private sector (Tekle, 2021). Strengthening the capacity of extension workers through continuous professional development and equipping them with the necessary tools and resources can enhance the support provided to mushroom farmers (Assefa, 2020). Additionally, promoting farmer-led extension models, where experienced mushroom farmers train their peers, can help bridge the knowledge gap and increase the reach of extension services (Mulugeta and Bekele, 2019).

Research and development

Research and development play a pivotal role in advancing mushroom production in Ethiopia. RandD efforts are focused on improving mushroom strains, optimizing cultivation techniques and developing new products that meet the needs of both domestic and international markets (Gebremariam and Tesfaye, 2021). Ethiopian research institutions, such as universities and agricultural research centers, have been actively involved in studying various aspects of mushroom production, including the identification of suitable species for cultivation under local conditions (Alemayehu, 2019).

One of the key areas of research has been the development of high-yielding, disease-resistant mushroom strains that are adapted to Ethiopia's diverse

agro-ecological zones (Fekadu, 2022). These efforts have led to the introduction of improved varieties of oyster and button mushrooms, which have become popular among farmers due to their higher productivity and marketability (Dawit and Ketema, 2020). Additionally, research on substrate optimization has resulted in the development of more efficient and sustainable cultivation methods, such as the use of locally available agricultural waste materials (Melaku, 2017).

Despite these advances, the impact of research and development on mushroom production in Ethiopia has been limited by several factors, including inadequate funding, lack of collaboration between research institutions and farmers and limited dissemination of research findings (Alemu, 2019). To maximize the benefits of research and development, there is a need for increased investment in research infrastructure, as well as stronger linkages between researchers, extension services and farmers (Tekle, 2021). Encouraging public-private partnerships in research and development can also accelerate the development and adoption of innovative technologies in mushroom farming (Mulugeta and Bekele, 2019).

Institutional and policy factors

Government policies

Government policies play a crucial role in shaping the development and sustainability of mushroom production in Ethiopia. The Ethiopian government has recognized the potential of mushroom farming as a means of diversifying agricultural production and improving food security (Gebremariam and Tesfaye, 2021). As a result, various policies have been introduced to promote the cultivation of mushrooms, including subsidies for inputs such as spawn and substrates, as well as tax incentives for smallholder farmers and cooperatives engaged in mushroom production (Alemayehu, 2019). Additionally, the government has implemented agricultural extension programs specifically targeting mushroom farmers, aimed at improving their technical skills and access to resources (Fekadu, 2022).

However, the effectiveness of these policies has been mixed, largely due to challenges in implementation and coordination across different levels of government (Assefa, 2020). In many cases, the lack of clear guidelines and enforcement mechanisms has limited the impact of government interventions, leaving many mushroom farmers without adequate support (Dawit and Ketema, 2020). Furthermore, the emphasis on staple crops such as maize and wheat in national agricultural policies has often overshadowed the promotion of non-traditional crops like mushrooms, resulting in insufficient funding and resources allocated to this sector (Mulugeta and Bekele, 2019). To address these issues, there is a need for more comprehensive and targeted policies that specifically address the unique challenges faced by mushroom farmers in Ethiopia (Melaku, 2017).

Institutional support

Institutional support is another key factor influencing the growth of mushroom production in Ethiopia. Various institutions, including government agencies, non-governmental organizations (NGOs) and research institutions, have been involved in promoting mushroom farming as a viable agricultural activity (Alemu, 2019). Government institutions such as the Ministry of Agriculture and regional agricultural bureaus have played a significant role in providing extension services, training and technical assistance to mushroom farmers (Fekadu, 2022). These institutions have also been involved in the distribution of inputs, such as spawn and substrates, as well as the establishment of demonstration farms to showcase best practices in mushroom cultivation (Gebremariam and Tesfaye, 2021).

NGOs and international development agencies have also been instrumental in supporting mushroom production in Ethiopia, particularly in areas where government resources are limited (Dawit and Ketema, 2020). These organizations often provide funding, technical expertise and capacity-building programs to help smallholder farmers establish and sustain mushroom farms (Alemayehu, 2019). For example, several NGOs have initiated projects aimed at improving the livelihoods of rural communities by promoting mushroom farming as a source of income and nutrition (Mulugeta and Bekele, 2019).

Despite these efforts, the level of institutional support for mushroom farmers remains insufficient, particularly in remote and underserved areas (Assefa, 2020). The fragmentation of responsibilities among different institutions, coupled with a lack of coordination and communication, has often resulted in duplication of efforts and inefficient use of resources (Melaku, 2017). To enhance institutional support for mushroom production, there is a need for greater collaboration among stakeholders, as well as the establishment of a centralized body to oversee and coordinate mushroom-related activities across the country (Tekle, 2021).

Land tenure and ownership

Land tenure and ownership issues are critical determinants of the scale and success of mushroom production in Ethiopia. Secure land tenure provides farmers with the confidence to invest in long-term agricultural activities, such as mushroom farming, which require significant initial investments in infrastructure and inputs (Fekadu, 2022). In Ethiopia, land ownership is governed by a complex system of customary and formal laws, with the government retaining ultimate ownership of all land (Gebremariam and Tesfaye, 2021). Farmers typically hold usufruct rights, which allow them to use the land but not to sell or mortgage it (Alemu, 2019).

This system of land tenure has both positive and negative implications for mushroom production. On the one hand, the allocation of land by local authorities provides

smallholder farmers with access to land for cultivation, which is essential for the expansion of mushroom farming (Dawit and Ketema, 2020). On the other hand, the lack of secure land ownership and the inability to use land as collateral for loans can limit farmers' access to credit and investment, thereby hindering the growth of their mushroom enterprises (Alemayehu, 2019). Additionally, disputes over land boundaries and tenure rights are common in many rural areas, creating uncertainty and discouraging investment in mushroom farming (Mulugeta and Bekele, 2019).

To address these challenges, there is a need for land tenure reforms that provide greater security and flexibility for farmers, including the possibility of long-term leases and the use of land as collateral for financing (Assefa, 2020). Such reforms would not only encourage investment in mushroom production but also enhance the overall productivity and sustainability of the agricultural sector in Ethiopia (Melaku, 2017). Furthermore, efforts to clarify and enforce land tenure rights, particularly in areas with high potential for mushroom cultivation, could help resolve disputes and create a more conducive environment for agricultural development (Tekle, 2021).

CONCLUSION

Mushroom production in Ethiopia is influenced by several key factors. Agro-climatic factors like climate, soil quality and geography determine suitable regions for cultivation. Socio-economic elements, including market demand, labor and financial resources, affect the scale and viability of farming. Technological factors, such as modern cultivation techniques, training and research, are essential for productivity and quality. Institutional and policy factors, including government policies, support and land tenure, provide the necessary framework for growth.

To improve mushroom production in Ethiopia, it is essential for the government to create targeted policies that support mushroom farming. This includes subsidies, tax incentives and better access to credit. Strengthening institutional support through enhanced extension services, collaboration among stakeholders and better coordination is also vital. Addressing land tenure issues with reforms that offer security and flexibility will encourage investment. Promoting modern cultivation techniques through training and demonstration farms, improving market access and increasing investment in research and development are critical steps to advance the sector.

Future research should focus on developing high-yield, disease-resistant mushroom strains suitable for Ethiopia's diverse agro-ecological zones. Research on optimizing substrate use with locally available materials could improve sustainability. Additionally, exploring the socio-economic impacts of mushroom farming and new markets for Ethiopian mushrooms are crucial areas of study. Finally, assessing the effectiveness of existing policies and support mechanisms can help identify gaps and guide improvements, ensuring the sector's sustainable growth.

Conflict of interest

The author declared that there is no conflict of interest.

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