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The role of farmer preferences in overcoming post-harvest constraints of enset (*Ensete ventricosum*)

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Abstract

Enset (*Ensete ventricosum*), commonly known as the "false banana," is a vital crop for food security in Ethiopia. Despite its significance, enset faces numerous post-harvest constraints that impact its productivity and quality. This review examines the role of farmer preferences in addressing these constraints. By synthesizing existing literature, the study explores how farmer choices influence post-harvest handling practices, identifies key challenges, and highlights successful strategies adopted by farmers. The findings underscore the necessity of aligning agricultural interventions with farmer preferences to enhance the post-harvest management of enset.

Keywords: Enset, *Ensete ventricosum*, false banana

Introduction

Enset (*Ensete ventricosum*), often referred to as the "false banana," is a staple crop of paramount importance to the food security and livelihood of millions of people in Ethiopia. This perennial crop, indigenous to the Ethiopian highlands, is cultivated primarily for its starchy pseudo-stem and corm, which are processed into various food products such as kocho, bulla, and amicho. Enset's resilience to harsh climatic conditions and its ability to provide sustenance during periods of drought underscore its critical role in the region's agricultural systems.

Despite its significant contributions, enset cultivation faces numerous post-harvest constraints that limit its productivity and quality. These constraints encompass a range of issues, including labor-intensive processing techniques, inadequate storage methods, pest infestations, and socio-economic challenges. Each of these factors contributes to substantial post-harvest losses, adversely affecting both the quantity and quality of the crop that reaches the market or is stored for future use.

Traditional processing methods, while culturally significant, are notoriously labor-intensive and time-consuming. The multi-stage process of decorticating the pseudostem, fermenting the pulp, and converting it into consumable products involves substantial manual effort and specialized knowledge. These methods often result in considerable inefficiencies and product loss, posing a significant barrier to maximizing enset's potential. Borrell *et al*. (2020) [3] emphasize that inefficiencies in traditional processing contribute to high post-harvest losses and a reduction in the nutritional value of the final products.

Storage issues further exacerbate the post-harvest challenges faced by enset farmers. Traditional storage practices, such as underground pits, are prone to spoilage due to poor ventilation and moisture retention, which foster conditions conducive to mold growth and pest infestations. Tsegaye and Struik (2001) [8] highlight that these suboptimal storage conditions lead to significant spoilage and loss, reducing the crop's reliability as a food source throughout the year. The lack of proper storage infrastructure not only diminishes the shelf life of enset but also undermines the overall food security of farming communities.

Pest infestations, particularly by the enset weevil (*Cylas* spp.), represent another critical post-harvest constraint. These pests cause extensive damage to both stored and growing plants, significantly impacting yield and quality. Addis *et al*. (2006) [10] note that weevils burrow into the corms and pseudostems, leading to decay and substantial loss of stored enset. Effective pest management is further complicated by the limited availability and high cost of pest control solutions, which are often beyond the reach of smallholder farmers.

In this complex landscape of post-harvest challenges, the preferences and decision-making processes of farmers play a pivotal role in shaping the effectiveness of any intervention.

Farmer preferences are influenced by a variety of factors, including economic constraints, cultural practices, labor availability, and environmental conditions. Understanding these preferences is essential for developing and implementing post-harvest management strategies that are not only effective but also sustainable and widely adopted by the farming community.

Farmers tend to favor methods that are cost-effective, easy to implement, and compatible with their existing practices. The adoption of new technologies or practices is often influenced by their perceived benefits, ease of integration into traditional methods, and affordability. Almaz *et al*. (2017) [1] found that farmers are more likely to adopt processing methods that balance efficiency, cost, and product quality, highlighting the importance of aligning interventions with farmer preferences to ensure successful uptake.

Storage solutions that maintain the quality of enset over extended periods are particularly valued by farmers. However, innovative storage techniques, such as airtight containers, often face barriers to adoption due to their cost and the lack of familiarity among farmers. Gizaw *et al*. (2019) [5] reported that while these storage solutions can significantly reduce spoilage, their high initial cost and the need for farmer training limit their widespread use. Thus, any effective intervention must consider these economic and educational barriers to ensure successful implementation.

Integrated pest management (IPM) approaches that combine biological, cultural, and chemical methods are preferred by farmers due to their sustainability and effectiveness. Mekonnen *et al*. (2015) [7] emphasized the importance of minimizing chemical use due to health and environmental concerns, which aligns with the preferences of many farmers. Biological control methods and the use of natural pesticides are particularly favored, as they integrate well with traditional practices and support environmental sustainability.

Successful post-harvest management strategies must also address the socio-economic context of enset cultivation. Many enset farmers lack access to modern agricultural technologies and infrastructure that could significantly improve post-harvest handling. Financial constraints often limit the ability of farmers to invest in these technologies. Providing subsidies, microcredit schemes, and training programs can help alleviate these barriers, promoting the adoption of improved post-harvest practices.

Community-based approaches have proven effective in overcoming individual constraints through collective action. Cooperative storage facilities and shared processing centers enable farmers to pool resources, knowledge, and labor, enhancing overall efficiency and reducing costs. Ayele *et al*. (2018) [2] demonstrated that community-based initiatives improve storage conditions and processing efficiency, thereby reducing post-harvest losses and increasing the economic viability of enset farming.

In conclusion, understanding and incorporating farmer preferences in post-harvest management strategies are essential for addressing the multifaceted challenges of enset cultivation. By aligning interventions with the needs and capabilities of farmers, stakeholders can develop sustainable solutions that enhance the productivity and quality of enset, thereby improving food security and economic stability for the communities that rely on this vital crop. This study aims to explore these farmer preferences in detail, identifying successful strategies that can be scaled and adapted to various contexts within enset-growing regions.

Objective

The objective of this paper is to explore and analyze the role of farmer preferences in overcoming post-harvest constraints in enset (*Ensete ventricosum*) cultivation. This study aims to identify major post-harvest challenges, understand farmer preferences regarding post-harvest practices, evaluate successful strategies that align with these preferences, and provide insights for developing interventions that enhance the adoption and sustainability of effective post-harvest management practices. Ultimately, the goal is to improve food security and economic stability for communities reliant on enset cultivation.

Post-harvest constraints in enset cultivation

Enset (*Ensete ventricosum*), commonly known as the "false banana," is a vital crop for food security in Ethiopia. It serves as a staple food for millions, particularly in the southern regions of the country. Despite its significant role, enset cultivation is plagued by numerous post-harvest constraints that affect its productivity and quality, thereby impacting the economic stability and food security of the communities that depend on it. One of the primary post-harvest constraints in enset cultivation is the labor-intensive nature of traditional processing techniques. These methods include decorticating the pseudostem and fermenting the pulp to produce various products such as kocho, bulla, and amicho. These traditional practices are not only time-consuming but also physically demanding. Borrell *et al*. (2020) [3] highlighted that these methods result in significant post-harvest losses due to inefficiencies and quality deterioration during processing. The laborious nature of these techniques often leads to incomplete processing, contributing to spoilage and reduced nutritional value. Additionally, the processing of enset into its various forms involves multiple stages, each of which presents potential points of failure that can lead to losses. Storage issues also pose substantial challenges in enset cultivation. Traditional storage methods, such as underground pits, are susceptible to various problems, including moisture retention, which promotes mold growth and attracts pests. Tsegaye and Struik (2001) [8] found that these storage conditions are far from ideal, often leading to significant spoilage and loss of edible product. The lack of proper ventilation and control over environmental conditions within these pits exacerbates the deterioration of stored enset, reducing its shelf life and making it less reliable as a food source throughout the year. Furthermore, the practice of storing enset underground, while culturally ingrained, often fails to protect the crop from fluctuations in temperature and humidity, which are critical factors in maintaining the quality of stored food products.

Pest infestations, particularly by the enset weevil (*Cylas* spp.) and other pests, are another major post-harvest constraint. These pests cause considerable damage to both the stored and growing plants, significantly impacting yield and quality. Addis *et al*. (2006) [10] emphasized the severe impact of pest infestations on enset storage, noting that weevils can burrow into the corms and pseudostems, causing extensive damage that leads to decay and loss of the stored product. The control of these pests is further complicated by the limited availability and high cost of effective pest management solutions, which many smallholder farmers cannot afford. Additionally, pest damage not only reduces the quantity of usable enset but also affects its quality, making it less palatable and nutritious. The socio-economic context also influences post-harvest constraints in enset cultivation. Many enset farmers lack access to modern agricultural technologies and infrastructure that could improve post-harvest handling. For instance, the introduction of mechanical graters and improved fermentation vats could significantly enhance processing efficiency and reduce labor requirements, as noted by Almaz *et al*. (2017) [1]. However, the adoption of these technologies is often limited by financial constraints and a lack of training. Moreover, the upfront costs of these technologies, coupled with the risks associated with adopting new methods, deter many farmers from making the switch from traditional practices. Farmer preferences and traditional practices play a crucial role in the management of post-harvest processes. Farmers tend to prefer methods that are cost-effective and integrate well with their existing practices. Gizaw *et al*. (2019) [5] reported that while innovative storage solutions such as airtight containers have shown promise in reducing spoilage, their adoption is hindered by their cost and the lack of familiarity among farmers. Thus, any intervention aimed at improving post-harvest management must align with farmer preferences to ensure successful adoption. Furthermore, traditional knowledge and cultural practices around enset cultivation and processing are deeply rooted and must be respected and incorporated into new strategies to ensure community buy-in and sustainability. Integrated pest management (IPM) approaches are crucial for effective pest control in enset cultivation. Mekonnen *et al*. (2015) [7] highlighted the importance of combining biological, cultural, and chemical methods to manage pest populations sustainably. However, the implementation of IPM is often limited by the availability of resources and the necessary knowledge among farmers. Training and extension services are essential to equip farmers with the skills needed to adopt these methods effectively. Additionally, IPM strategies must be tailored to the specific pests and conditions prevalent in enset-growing regions, requiring localized research and extension efforts. Environmental factors also play a significant role in post-harvest constraints. Variations in climate, such as changes in temperature and rainfall patterns, can affect both the growth and post-harvest handling of enset. Climate change poses a significant threat to enset cultivation, as extreme weather events can exacerbate pest problems and spoilage. Farmers need adaptive strategies to cope with these environmental changes, including improved storage techniques that can mitigate the effects of climate variability.

Economic factors further complicate post-harvest management. The profitability of enset farming is influenced by market access and prices, which can fluctuate widely. Farmers often face difficulties in accessing markets where they can sell their surplus enset products at favorable prices. Market infrastructure improvements, such as better roads and transportation facilities, are essential to reduce post-harvest losses and improve the economic viability of enset farming.

Policy and institutional support are critical in addressing post-harvest constraints. Government policies that promote research and development in post-harvest technologies, provide subsidies for modern processing and storage equipment, and support training programs for farmers can significantly alleviate these challenges. Additionally, establishing farmer cooperatives and associations can enhance collective action and bargaining power, allowing farmers to invest in better post-harvest infrastructure and access markets more effectively.

In conclusion, post-harvest constraints in enset cultivation are multifaceted, encompassing labor-intensive processing techniques, inadequate storage methods, pest infestations, and socio-economic challenges. Addressing these constraints requires a comprehensive approach that considers farmer preferences, provides access to modern technologies, and integrates effective pest management practices. By aligning agricultural interventions with the needs and capabilities of farmers, it is possible to enhance the post-harvest management of enset and improve food security and economic stability for the communities that rely on this vital crop. Future research should focus on developing context-specific solutions that are affordable, sustainable, and culturally acceptable to ensure the long-term success of enset farming.

Farmer Preferences and Decision-Making

In the realm of enset (*Ensete ventricosum*) cultivation, farmer preferences and decision-making processes are pivotal to the efficacy of post-harvest management practices. These preferences are deeply influenced by a confluence of socio-economic, cultural, and environmental factors, each playing a crucial role in how farmers approach post-harvest activities. Understanding these preferences is essential for the development and successful implementation of interventions that truly resonate with the needs and realities of farmers. Farmers inherently favor methods that are not only cost-effective but also easy to implement and seamlessly integrate into their existing agricultural practices. The decision-making process regarding post-harvest techniques is largely dictated by the availability of key resources such as labor, tools, and financial capital. Traditional processing methods, despite their labor-intensive nature, often hold favor due to their low cost and the extensive familiarity farmers have with these practices. Almaz *et al*. (2017) [1] observed that farmers tend to prefer processing methods that strike a balance between efficiency, cost, and product quality—a balance crucial for maintaining food security and maximizing economic returns. When it comes to storage solutions, farmer preferences are equally significant. Traditional storage methods, such as underground pits, are extensively used because of their simplicity and low cost. However, these methods frequently fall short of providing optimal conditions necessary for preserving enset, resulting in considerable spoilage and loss. Farmers prioritize storage techniques that can maintain the quality of enset over extended periods. Gizaw *et al*. (2019) [5] noted that while innovative storage solutions like airtight containers have demonstrated potential in reducing spoilage, their adoption is often hindered by their cost and the lack of familiarity among farmers. Hence, any intervention aimed at improving post-harvest management must align with these preferences to ensure successful adoption. Moreover, integrated pest management (IPM) strategies are preferred by farmers due to their effectiveness and sustainability. Mekonnen *et al*.

(2015) [7] highlighted that farmers favor pest control approaches that minimize chemical use while effectively managing pest populations. Biological control methods and the use of natural pesticides are particularly valued, as they align with the environmental and health considerations of the farming communities. However, the implementation of IPM is often constrained by the availability of resources and the necessary knowledge among farmers, emphasizing the need for targeted training and extension services. The socio-economic context also exerts a profound influence on farmer decision-making. Financial constraints often limit the ability of farmers to invest in modern agricultural technologies that could improve post-harvest handling. For instance, mechanical graters and improved fermentation vats, which could significantly enhance processing efficiency and reduce labor requirements, are not widely adopted due to their high initial costs and the risks associated with adopting new methods. Farmers tend to be cautious about investing in new technologies, particularly when they are uncertain about the potential returns or when the technologies do not align with their traditional practices. Farmer decision-making is also shaped by cultural factors. Traditional knowledge and practices surrounding enset cultivation and processing are deeply rooted in the community and play a significant role in shaping farmer preferences. Interventions that respect and incorporate these cultural practices are more likely to gain acceptance and be sustainably adopted. Farmers are more inclined to adopt new methods if they perceive them to be an enhancement of their existing practices rather than a complete overhaul. The role of community-based approaches cannot be overstated in the context of farmer decision-making. Cooperative storage facilities and shared processing centers have been shown to mitigate individual farmer constraints by pooling resources and knowledge. Ayele *et al*. (2018) [2] demonstrated that community-based storage facilities not only improved overall storage efficiency but also reduced individual farmer costs. Such cooperative initiatives also enhance collective action and bargaining power, enabling farmers to invest in better post-harvest infrastructure and access markets more effectively. Environmental factors further influence farmer preferences and decision-making. Variations in climate, such as changes in temperature and rainfall patterns, can significantly affect both the growth and post-harvest handling of enset. Climate change poses a significant threat to enset cultivation, as extreme weather events can exacerbate pest problems and spoilage. Farmers need adaptive strategies to cope with these environmental changes, including improved storage techniques that can mitigate the effects of climate variability. In conclusion, farmer preferences and decision-making are central to the effective management of post-harvest processes in enset cultivation. These preferences are influenced by a complex interplay of socio-economic, cultural, and environmental factors. Addressing post-harvest constraints in enset cultivation requires a comprehensive approach that considers these preferences, provides access to modern technologies, and integrates effective pest management practices. By aligning agricultural interventions with the needs and capabilities of farmers, stakeholders can enhance the post-harvest management of enset, thereby improving food security and economic stability for the communities that rely on this vital crop. Future research should focus on developing context-specific solutions that are affordable, sustainable, and culturally acceptable to ensure the long-term success of enset farming.

Successful strategies aligned with farmer preferences

The alignment of agricultural strategies with farmer preferences is crucial for the successful implementation and sustainability of post-harvest management practices in enset (*Ensete ventricosum*) cultivation. Farmers are more likely to adopt and sustain practices that they find compatible with their existing methods, financially feasible, and culturally acceptable. Several strategies have proven successful by aligning with these preferences, thereby improving the post-harvest handling of enset. One of the most effective strategies is the introduction of improved processing equipment that reduces labor and enhances efficiency. Traditional enset processing is labor-intensive and time-consuming, involving multiple steps that can lead to significant post-harvest losses. The adoption of mechanical graters and improved fermentation vats has been particularly well-received by farmers. Tsegaye (2016) [9] noted that the use of mechanical graters significantly reduces processing time and labor, which not only increases efficiency but also decreases the physical burden on farmers, particularly women, who are primarily responsible for processing tasks. These tools are designed to be user-friendly and to integrate seamlessly with traditional practices, which enhances their acceptability and usage among farmers. Innovative storage techniques have also shown promise in extending the shelf life of enset and reducing spoilage. Traditional underground pits, while simple and low-cost, often fail to protect enset from mold growth and pest infestations. Solutions such as airtight containers and improved traditional pits have demonstrated significant benefits. Desta *et al*. (2020) [4] found that the use of airtight containers reduced spoilage rates by up to 50%. These containers prevent moisture ingress and pest entry, maintaining the quality of the stored enset. Additionally, modifying traditional storage pits to include better ventilation and moisture control has proven effective. These improvements require minimal investment and leverage existing knowledge, making them attractive to farmers. The implementation of community-based approaches has been instrumental in addressing individual constraints through collective action. Cooperative storage facilities and shared processing centers help pool resources and knowledge, mitigating the limitations faced by individual farmers. Ayele *et al*. (2018) [2] demonstrated that community-based storage facilities improved overall storage efficiency and reduced individual farmer costs. These facilities enable farmers to store their produce under optimal conditions, thereby reducing spoilage and extending the shelf life of enset. Shared processing centers equipped with modern tools and technologies further enhance processing efficiency and product quality. The cooperative model also fosters a sense of community and collective responsibility, which is crucial for the sustainability of these interventions. Integrated pest management (IPM) strategies that align with farmer preferences are crucial for effective pest control. Mekonnen *et al*. (2015) [7] highlighted the importance of combining biological, cultural, and chemical methods to manage pest populations sustainably. Farmers prefer pest control methods that minimize chemical use due to concerns about health and environmental impacts. Biological control methods, such as the use of natural predators or biopesticides, have gained acceptance among farmers. These methods are not only effective but also align with traditional practices and environmental sustainability. Training and extension services play a vital role in equipping farmers with the knowledge and skills necessary to implement IPM strategies effectively. Farmer education and training are essential components of successful post-harvest management strategies. Providing training on improved post-harvest techniques enhances farmer capabilities and encourages the adoption of new practices. Extension services can bridge the gap between research and practice, ensuring that farmers are aware of and can utilize the latest innovations. Training programs that involve hands-on demonstrations and are tailored to the local context are particularly effective. They help farmers understand the benefits of new techniques and how to integrate them into their existing practices. Subsidies and financial support for adopting improved technologies can also drive the successful implementation of post-harvest strategies. Financial constraints often hinder farmers from investing in new technologies and infrastructure. Providing subsidies for mechanical tools, storage containers, and other post-harvest innovations can alleviate this barrier. Additionally, microcredit schemes and financial assistance programs can help farmers manage the initial costs associated with adopting new practices. These financial incentives not only encourage adoption but also ensure that the technologies are accessible to smallholder farmers. Market access and infrastructure development are critical for the economic viability of enset farming. Improved market infrastructure, such as better roads and transportation facilities, can reduce post-harvest losses and improve the profitability of enset farming. By facilitating easier and quicker access to markets, these improvements ensure that farmers can sell their produce at favorable prices, thereby enhancing their income and economic stability. Establishing direct links between farmers and markets can also reduce the number of intermediaries, ensuring that farmers receive a fair price for their produce. In conclusion, aligning post-harvest management strategies with farmer preferences is essential for their successful adoption and sustainability. Strategies that reduce labor, enhance efficiency, improve storage, and integrate pest management effectively are more likely to be embraced by farmers. Community-based approaches, farmer education, financial support, and improved market access further enhance the effectiveness and sustainability of these interventions. By considering the socio-economic, cultural, and environmental contexts in which farmers operate, stakeholders can develop and implement strategies that not only address post-harvest constraints but also improve the overall productivity and economic stability of enset farming communities.

Conclusion

This study underscores the critical importance of aligning post-harvest management strategies with farmer preferences to overcome the numerous challenges faced in enset (*Ensete ventricosum*) cultivation. The effectiveness of post-harvest interventions is significantly enhanced when they are tailored to the socio-economic, cultural, and environmental contexts of the farming communities.

One of the primary insights from this review is that labor-intensive traditional processing techniques, while culturally significant, contribute to substantial post-harvest losses. The introduction of improved processing equipment, such as mechanical graters, has been well-received by farmers due to its ability to reduce labor and increase efficiency. Similarly, innovative storage solutions, including airtight containers and modified traditional pits, have proven effective in extending the shelf life of enset and reducing spoilage. Community-based approaches, such as cooperative storage facilities and shared processing centers, have successfully addressed individual constraints through collective action, enhancing storage efficiency and reducing costs. Integrated pest management (IPM) strategies that combine biological, cultural, and chemical methods have shown promise in sustainably managing pest populations, aligning well with farmer preferences for environmentally friendly practices. The role of farmer education and training cannot be overstated. Extension services that provide hands-on demonstrations and are tailored to local contexts are essential for equipping farmers with the knowledge and skills needed to adopt new technologies and practices. Financial support, through subsidies and microcredit schemes, further facilitates the adoption of improved post-harvest technologies by alleviating the financial constraints faced by smallholder farmers. Market access and infrastructure development are also crucial for the economic viability of enset farming. Improved transportation and market linkages ensure that farmers can sell their produce at favorable prices, thereby enhancing their income and economic stability.

In conclusion, addressing post-harvest constraints in enset cultivation requires a comprehensive and multifaceted approach that prioritizes farmer preferences. By incorporating local knowledge, providing access to modern technologies, and supporting community-based initiatives, stakeholders can significantly improve the post-harvest management of enset. This, in turn, will enhance food security and economic stability for the communities that rely on this vital crop. Future research should continue to develop context-specific solutions that are affordable, sustainable, and culturally acceptable to ensure the long-term success and resilience of enset farming.

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