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Post-harvest management of millets: A pathway to sustainability and food security

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Abstract

Millet utilization, despite nutritional and climate-resilient advantages, is limited by post-harvest constraints. This communication analyses critical challenges, including inadequate processing technology, suboptimal storage, and limited market access. Optimized post-harvest operations, encompassing cleaning, drying, dehusking, and controlled atmosphere storage, are crucial for maintaining millet quality and market value. Value addition through processing enhances consumption and economic viability. Efficient post-harvest management increases farmer profitability, minimizes losses, and supports sustainable agriculture. Policy interventions, technological advancements, and consumer education are essential for mainstreaming millets. Improved post-harvest practices are key to realizing millet's potential for food security, rural development, and sustainability.

Keywords: Millets; Post-harvest techniques; Sustainability; Food preservation; Value addition.

Introduction

Millets, often referred to as "Nutri-cereals," are gaining global recognition due to their high nutritional value, resilience to climate change, and ability to thrive in semi-arid regions. These small-seeded grains, including varieties such as pearl millet, finger millet, foxtail millet, and sorghum, have been cultivated for centuries, primarily in India, Africa, and China [26,27]. Despite their numerous advantages, the lack of proper post-harvest management has hindered their widespread adoption. Effective post-harvest practices are crucial to preserving quality, minimising losses, and enhancing marketability [18].

Importance of post-harvest management

Post-harvest management refers to a series of processes and techniques used to handle crops after harvesting. This phase plays a significant role in maintaining the quality and nutritional value of millets while reducing food losses. The primary objectives of post-harvest management include minimizing post-harvest losses, preserving nutritional content, enhancing market value, ensuring food safety, extending shelf life, and supporting food security and rural livelihoods [1].

Key challenges in post-harvest management of millets

Millets, despite their numerous benefits, face several post-harvest challenges that impact their adoption and marketability [4,6,13,18,21]. Some of the key challenges include:

1. **Lack of modern equipment:** Traditional processing methods, such as manual threshing and pounding, lead to higher labour costs and inefficiencies.
2. **Storage issues:** Millets are susceptible to fungal contamination, insect infestation, and nutrient degradation if stored under improper conditions.
3. **Limited market awareness:** The demand for millet remains

lower than other cereals like rice and wheat due to limited consumer awareness and preference.

4. **Processing complexity:** Some millet varieties have hard, inedible husks that require dehusking before consumption, making processing difficult and labour-intensive.

5. **Low economic incentives for farmers:** Due to lower farm gate prices compared to mainstream cereals, farmers often hesitate to cultivate millets extensively.

Post-harvest processes and techniques

To maximize millet utilization and ensure its longevity, a structured post-harvest process must be followed. The major steps include:

- **Cleaning:** Cleaning is the initial stage where impurities such as dirt, stones, and chaff are removed. This process enhances grain quality and prevents contamination during storage and processing. Methods used include winnowing, which uses air currents to separate lighter particles from heavier grains, and aspirators and sieves, which are mechanical separation techniques that efficiently remove impurities [5,24].

- **Drying:** Drying is a crucial step to reduce the moisture content of millets and prevent microbial growth. Millets should be dried to a moisture level of less than 10% for safe storage. Drying techniques include sun drying, which is traditional yet cost-effective but susceptible to contamination, and mechanical drying, which uses controlled artificial heat sources to ensure uniform drying and prevent fungal growth [16,17].

- **Dehusking and milling:** Millets are categorized into naked grains (e.g., sorghum, pearl millet, and finger millet) and husked grains (e.g., foxtail millet, barnyard millet, and little millet). Husked millets require dehusking before consumption. The two main types of milling are primary processing, which includes dehusking, grinding, and sieving to produce flour, semolina, or whole grains, and secondary processing, which involves converting millets into Ready-To-Cook (RTC) or Ready-To-Eat (RTE) products such as flakes, popped millets, and extruded snacks [2].

- **Storage:** Proper storage conditions prevent post-harvest losses due to pest infestation, mold formation, and nutrient degradation. Essential storage practices include temperature control, where millets should be stored below 25°C to maintain quality; moisture management, where keeping moisture levels below 10% reduces fungal growth and prevents spoilage; pest protection, using airtight containers, insect-resistant bags, and fumigation techniques to prevent pest infestation; and avoiding direct sunlight, where millets should be stored in a cool, dark place to retain their nutritional properties [3,9].

- **Value addition and processing:** Value addition enhances millet consumption by improving their convenience, taste, and marketability. Popular processed millet products include flours and semolina, used for making rotis, porridges, and baked goods; popped and flaked millets, which are nutritious breakfast alternatives to conventional cereals; extruded millet products, such as ready-to-eat snacks like millet-based pasta and energy bars; and fermented products, including millet-based beverages and probiotic-rich foods that improve gut health [10,12,20].

Packaging and labelling of millets

Proper packaging protects millets from spoilage, contamination, and physical damage. In the current retail market, millet packaging primarily relies on three key materials: Polyethylene (PE), Polypropylene (PP), and paperboard. Additionally, glass, Oriented Polypropylene (OPP), laminates, and metals are utilized based on the specific requirements of the food product. For rigid packaging, materials such as glass, paperboard, high-density polyethylene, metal cans, and tetra packs are commonly used. Meanwhile, polypropylene and OPP are preferred for flexible packaging and stand-up pouches [11].

A recent study by Divija et al. [7] explored the effectiveness of active packaging for foxtail millet storage by incorporating oxygen scavenger sachets to mitigate the infestation of *Tribolium castaneum*, a common pest in stored grains. The findings revealed a 100% mortality rate of the beetles in grain pouches containing oxygen scavengers, as these sachets effectively absorbed all available oxygen, creating an oxygen-depleted environment unfavourable for pest survival. Among the various packaging materials evaluated, multi-layered pouches demonstrated the highest efficacy when combined with oxygen scavengers. This study highlights the significant potential of active packaging in enhancing the storage stability and safety of millets.

Economic and environmental benefits of millet processing

Efficient post-harvest management of millets not only benefits farmers but also contributes to environmental sustainability. Key advantages include increased farmer income, as value-added millet products fetch higher prices, improving rural livelihoods; reduction in food waste, as proper storage and processing minimize post-harvest losses; lower carbon footprint, as millets require less water, fertilizers, and pesticides than rice and wheat, making them a sustainable choice for agriculture; and contribution to Sustainable Development Goals (SDGs), such as SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) [8,15,19,22,23,25].

Future prospects and policy support

To enhance millet adoption and marketability, policymakers, researchers, and industry stakeholders must collaborate to invest in modern processing technologies, strengthen market linkages, incentivize farmers, and promote dietary awareness. Encouraging mechanized millet processing can improve efficiency and reduce labour dependency. Developing better supply chains, e-commerce platforms, and millet-based product promotions will increase consumer awareness. Government policies should provide subsidies and fair pricing mechanisms to encourage millet cultivation. Conducting awareness campaigns highlighting the health benefits of millets will drive consumer demand.

Conclusion

Post-harvest management of millets plays a pivotal role in ensuring food security, reducing losses, and improving economic returns for farmers. With technological advancements, proper storage methods, and value-addition strategies, millets can become a mainstream staple in global diets. Encouraging millet consumption and improving post-harvest processes will not only benefit farmers and consumers but also contribute to sustainable agricultural practices and climate resilience.

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