Model Framework for Setting Farmer-Friendly Millet Processing Units

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OPEN ACCESS

Keywords

Shree Anna, Primary Processing Units, Machinery Layout, Infrastructure, FPOs

How to cite this article:

Sangappa., Meghana, G., Rafi, D., Prashanth, E. S., Shiva, K. and Babu, K. S. 2025. Model Framework for Setting Farmer-Friendly Millet Processing Units. *Vigyan Varta* 6 (10): 155-163.

ABSTRACT

Millet primary processing units are emerging as critical interventions in strengthening the farm-to-market journey of Shree Anna (millets). By enabling the cleaning, dehusking, grading, and polishing services these units substantially reduce post-harvest losses and ensure consistent supply of quality grains. Their role extends beyond processing, as they serve as growth hubs for Farmer Producer Organizations (FPOs) and rural entrepreneurs. To support the establishment of such facilities, ICAR-IIMR has developed a model machinery layout that offers a practical blueprint for efficient operations. This design provides information on strategic placement of millet primary processing unit in cost-effective, safe, and farmer friendly way. This model demonstrates how technology and infrastructure integrated thoughtfully for enhancing the accessibility and efficiency of machines in rural context. These processing units also open avenues for value addition, entrepreneurship, and employment generation. By improving the availability of nutritious millets, they contribute to healthier diets, dietary diversification, and sustainable food systems. Ultimately, millet processing units become enablers of farmer prosperity, rural enterprise development, and ecological resilience.

INTRODUCTION

Millets are broadly classified into major and minor millets based on grain size and processing needs. Major millets like sorghum (jowar), pearl millet (bajra), and finger millet (ragi) have larger grains and generally require minimal processing such as cleaning and milling before consumption, with finger millet often ground directly into flour. In contrast, minor millets such as foxtail, kodo, little, barnyard, and proso millets are much smaller and tightly covered with husks, making dehusking and dehulling essential before they can be consumed. Processing is crucial not only for making millets edible but also for adding value—transforming them into flours, flakes, or ready-to-cook products that enhance consumer acceptance and demand. However, despite their resilience in the field, millets remain highly vulnerable post-harvest. Without efficient processing, grains are prone to impurities, pest infestation, and physical damage, reducing both market value and consumer preference. Traditionally, farmers relied on manual or small-scale mechanical methods such as pounding, hand dehusking, and sun drying (Figure 1). While effective at a basic level, these practices are labor-intensive, time-consuming, and often yield uneven quality (Amitabh *et al.,* 2024). In contrast, modern primary processing units (PPUs) streamline these operations (Figure 2) with machines designed for cleaning, destoning, dehulling, and grading grains, ensuring uniform quality with minimal losses. Modern units not only enhance the appearance, taste, and cooking quality of millets but also improve shelf life and food safety by eliminating contaminants (Naik *et al.,* 2022). For rural communities, particularly farmer producer organizations (FPOs) and self-help groups, localized PPUs act as engines of empowerment. They open avenues for value addition, entrepreneurship, and higher incomes by enabling direct sales of quality products. Moreover, the availability of clean, market-ready millet supports dietary diversity and nutritional security, aligning with India's goals of food security and sustainable agriculture. By replacing laborious traditional methods (Figure 1) with modern, accessible technologies (Figure 2), PPUs make millet cultivation more profitable, convenient, and farmer-friendly while preserving the nutritional and cultural heritage of Shree Anna.

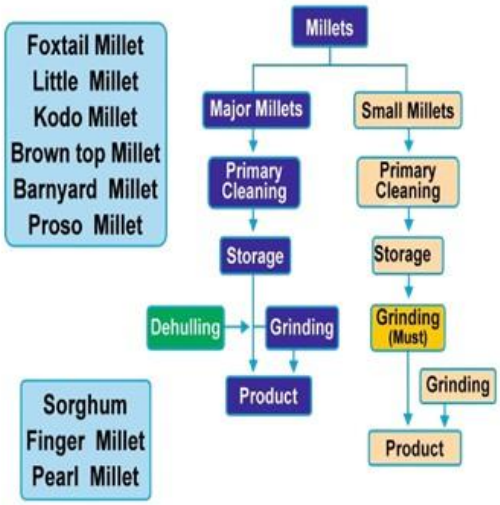

Figure 1. Traditional methods of Millet

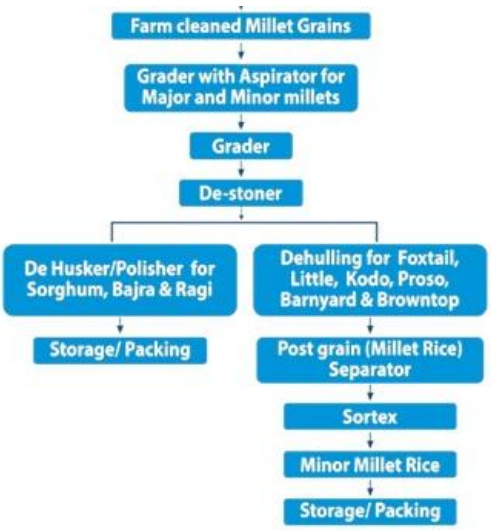

Figure 2. Modern methods of Millet processing

Importance of Millet Processing in Sustainable Farming

Millet processing represents a vital stage in the farm-to-market continuum, serving as the link that determines how effectively raw harvests are converted into market-ready products. Unlike many other cereals, freshly harvested millets often contain impurities, uneven grain sizes, and husks that make them unsuitable for direct consumption or marketing. Through systematic cleaning, dehusking, grading, and polishing, primary processing transforms these raw grains into clean, uniform lots that comply with food safety and quality standards. The benefits of processing extend beyond cosmetic improvements. Enhanced grain quality improves cooking properties, taste, and nutritional accessibility, making millets more appealing and convenient for households, retailers, and institutional buyers such as schools, hospitals, and public distribution systems. Properly processed millets also demonstrate better storability, reducing the risk of spoilage and post-harvest losses, which are often significant in rural and tribal areas. By improving shelf-life and ensuring consistent supply, processing strengthens consumer trust and market demand. From a farming systems perspective, millet processing contributes directly to sustainability. It adds economic value at the local level, opening avenues for Farmer Producer Organizations (FPOs), self-help groups, and rural entrepreneurs to engage in value addition, branding, and marketing. The establishment of primary processing units creates localized employment opportunities, reduces dependence on middlemen, and fosters rural enterprise development. Moreover, by increasing consumer accessibility to nutritious, climate-resilient millets, processing supports dietary diversification and contributes to long-term food and nutritional security (Suma and Urooj, 2017). In this way, millet processing is not merely a technical step but a strategic intervention that integrates farm productivity with market potential, farmer prosperity, and sustainable food systems.

Key Benefits:

1. **Enhanced Food Safety:** Cleaning, aspiration, and destoning remove dust, stones, chaff, and metallic fragments. Dehulling and polishing reduce microbial load and defects, ensuring compliance with food safety norms.

2. **Longer Shelf Life and Convenience:** Grading and moisture-aware handling slow rancidity and pest damage. Ready-to-cook formats like dehulled grains, flour, or semolina save time and encourage regular consumption.

3. **Higher Farmer Income:** Primary processing near the farm gate upgrades bulk grain to higher-value products, reducing dependence on middlemen. Shared facilities or custom hiring lower costs while improving profitability.

4. **Stronger FPO Systems and Product Diversification:** Processing hubs allow FPOs to aggregate grains, enforce quality, and branch into secondary products like flours, flakes, and ready-to-eat items, stabilizing income and building brand recognition.

5. **Sustainability and Resilience:** Processing reduces post-harvest losses, improves storability, lowers transport emissions, and strengthens rural economies while conserving water and land.

Role in Quality Improvement

Processing plays a crucial role in upgrading the quality of millets by ensuring uniformity in size, color, and overall cleanliness. These improvements significantly enhance the

market appeal of millets, both in domestic and international markets. Through systematic grading and polishing, processors can cater to varied consumer segments: polished grains are preferred in urban retail due to their visual appeal and ease of cooking, while semi-processed or minimally processed grains retain higher fiber content and are well-suited for traditional diets, niche health markets, and food industries. Furthermore, the segregation of millet varieties during processing enables producers to meet diverse consumer preferences and targeted nutritional needs, thereby strengthening market linkages and expanding consumption.

Reducing Post-Harvest Losses

Primary Processing Units (PPUs) are essential in mitigating significant post-harvest losses often caused by inadequate storage, pest infestations, and improper handling practices. The incorporation of pre-cleaners and graders ensures that damaged or contaminated grains are separated, improving the quality and safety of the final product (Yousaf *et al.,* 2017). Additionally, ventilated storage systems and scientific grain handling practices protect harvests from excess moisture, pests, and fungal growth. These interventions not only extend shelf-life and maintain nutritional integrity but also enhance farmer incomes by ensuring higher recovery rates of marketable produce (Rani *et al.,* 2018). At the macro level, such practices contribute to national food security by reducing wastage and ensuring a steady supply of millets throughout the year.

Challenges in Establishing Millet Primary Processing Units (PPUs)

While millet PPUs play a transformative role in strengthening value chains, their establishment is often constrained by several challenges:

1. **High Initial Investment:** Setting up modern millet processing units requires substantial capital for machinery, infrastructure, storage, and utilities. For smallholder farmers and FPOs, mobilizing such investments is difficult without adequate financial **support or credit facilities.**

2. **Limited Access to Technology:** Many rural entrepreneurs and FPOs lack awareness of advanced processing technologies and efficient machinery layouts. Inadequate technical knowledge often leads to under-utilization of equipment or reliance on outdated methods that compromise quality and efficiency.

3. **Operational and Maintenance Issues**: Skilled manpower for operating, repairing, and maintaining specialized machines is often scarce in rural areas. Frequent breakdowns, irregular power supply, and lack of timely servicing increase operational costs and disrupt processing schedules.

4. **Supply Chain Constraints:** Seasonal availability of millets, small-scale production, and dispersed farmer holdings limit the consistent flow of raw material to PPUs. Without assured aggregation and procurement systems, many units face challenges in running at full capacity.

5. **Quality Standards and Market Linkages:** Meeting stringent domestic and export quality standards requires uniform processing, testing, and certification facilities, which are often unavailable in rural settings. Additionally, weak market linkages and lack of branding or marketing skills hinder value realization.

6. **Policy and Institutional Gaps:** Despite government support for millet promotion, delays in policy implementation, limited

convergence between departments, and insufficient handholding mechanisms create barriers to scaling PPUs. FPOs and small enterprises often struggle to navigate regulatory requirements and access subsidies or schemes.

7. **Socio-Economic Barriers:** Low levels of farmer awareness, reluctance to adopt new technologies, and risk aversion limit participation in processing ventures. Gender and social disparities may further restrict equitable involvement in value addition opportunities.

Essential Machinery for Primary Millet Processing

Establishing a Millet Primary Processing Unit (PPU) requires a combination of machines designed to handle cleaning, dehusking, grading, and polishing operations. Each piece of equipment plays a critical role in ensuring that raw millet harvested from farms is transformed into clean, safe, and market-ready grain (Bangar *et al.,* 2022). The following are the key categories of machinery:

1. Pre-Cleaner

- Removes dust, stones, stalks, chaff, and other light impurities from raw millets.
- Ensures only healthy grains enter the processing line, reducing wear on subsequent machines.

2. Destoner

- Separates stones and heavier particles that are similar in size to grains but differ in density.
- Essential for meeting food safety standards and consumer acceptance.

3. Grader/Sorter

- Segregates grains based on size and shape.
- Helps in producing uniform grain lots, improving appearance and cooking quality.

4. Dehusker/Dehuller

- Removes the hard outer husk of millets such as foxtail, little millet, barnyard, and kodo.
- Critical for making millets suitable for human consumption and further processing.

5. Aspirator

- Uses air flow to separate lighter particles such as husk, immature grains, and broken material.
- Enhances efficiency in producing clean and safe grain batches.

6. Polisher

- Improves grain appearance, texture, and shelf life by polishing dehusked grains.
- Produces shiny, uniform grains preferred in urban and export markets, while semi-polished outputs cater to traditional diets.

7. Grain Grader cum Separator

- Separates broken grains from whole ones.
- Ensures uniformity for packaging and meets market grading standards.

8. Storage Bins and Conveying System

- Well-ventilated bins prevent moisture build-up and pest infestation.
- Conveyors facilitate smooth grain movement across units, reducing manual handling losses.

9. Packaging Unit

- Includes weighing, sealing, and labeling machines.

- Ensures product traceability, branding, and compliance with retail/wholesale requirements.

Key parameters to consider before establishing a PPU:

1) **Location & Infrastructure:** Choose a site with at least 24×52 ft space, good ventilation, and wide entry points to ensure smooth movement of materials and safe operation of machinery.

2) **Workflow Design:** Arrange machines in a logical sequence with adequate spacing to prevent congestion, reduce handling, and maintain safety for operators.

3) **Power Requirements:** Ensure stable electricity to run 2–15 HP machines efficiently, and provide backup options like generators or solar to avoid downtime.

4) **Storage Facilities:** Provide sufficient ventilated storage for both raw and processed grains to protect quality and reduce post-harvest losses.

5) **Scalability:** Design the unit keeping future growth in mind, allowing expansion into value-added products such as flours, flakes, or ready-to-eat foods.

Scale of PPUs:

i) **Small scale units:** 200–500 kg/day, suitable for local FPOs, basic machines.

ii) **Medium scale units:** 500–1,500 kg/day, district-level marketing, integrated machinery.

iii) **Large scale units:** 2,000+ kg/day, institutional and export markets, automated systems, advanced quality control.

Machinery Layout and Workflow Planning

Principles of efficient layout design: A millet processing unit functions best when machines are organized in a stepwise order, allowing grain to move without backflow or confusion. Proper distancing between equipment, along with adequate ventilation and storage placement, creates a safe and user-friendly environment. In this arrangement, raw materials enter near the storage point, flow through successive machines, and exit as finished products all without congestion or repetitive handling.

Streamlined equipment positioning: The setup is designed as a straight processing line. Grain first passes through the Pre-Cleaner (Destoner cum Grader cum Aspirator), then moves to the Dehusker, followed by the Dehuller, and finally reaches the Post Rice Separator for finishing. Each stage is connected with planned gaps of about 2.5–3 feet for smooth grain transfer, easy upkeep, and worker safety. A 26-foot central corridor supports trolley movement and worker circulation, while windows and exhausts keep the unit free from dust and heat buildup.

Workflow to minimize time, labor, and losses: The system integrates grain reception, processing, and storage within the same space, ensuring a continuous line of operation. Raw millet enters centrally, moves through every machine in sequence, and then is stored or packed. This minimizes lifting, manual effort, and grain wastage. Proper spacing not only lowers accidents and wear but also reduces turnaround time, making the setup more economical and farmer-friendly.

Optimal Layout Design for Millet Primary Processing Units

Smart design overview: The illustrated 26 ft × 26 ft unit showcases how a compact space can host all primary machines needed for

millet processing. From intake to packaging, the design emphasizes maximum utility of every square foot, offering FPOs and small enterprises a practical model to follow.

Logical flow of machines: The layout is designed to follow a clear step-by-step process, beginning with the intake of raw materials and progressing through cleaning, dehusking, and dehulling before the final stage of preparation. At the entrance, the Pre-cleaner (Destoner cum Grader cum Aspirator, 3 HP) is placed, followed by the Dehusker (15 HP) and the Dehuller (2 HP), with the sequence concluding at the Post Rice Separator (5.5 HP) for the final grading and separation of grains.

Infrastructure requirements: The unit includes two raw material storage rooms (8 ft each) located near the entrance for easy access. Ventilation is maintained by windows along the walls, while exhaust fans on both sides ensure dust removal. A 6.5 ft wide entry gate supports the free movement of raw materials, finished goods, and maintenance equipment.

Space and safety considerations: The design accounts for 3 ft spacing between machines, 2.5 ft clearance from the walls, and 10 ft gaps near storage areas. These provisions ensure worker safety, easy equipment maintenance, and smooth material handling while meeting safety standards.

Energy use and future expansion: The combined machinery requires about 25.5 HP, making the unit well-suited for small to medium-scale operations. Space has also been allocated for secondary machinery, enabling the unit to diversify into value-added millet products such as flour, flakes, and ready-to-eat foods.

Benefits for farmers and FPOs: This standardized layout can serve as a ready-to-adopt model for rural millet enterprises. It provides clear dimensions, placement strategies, and operational guidelines that can be replicated across different locations. By maximizing efficiency and minimizing costs, this design strengthens the business potential of farmer groups and ensures sustainable millet processing.

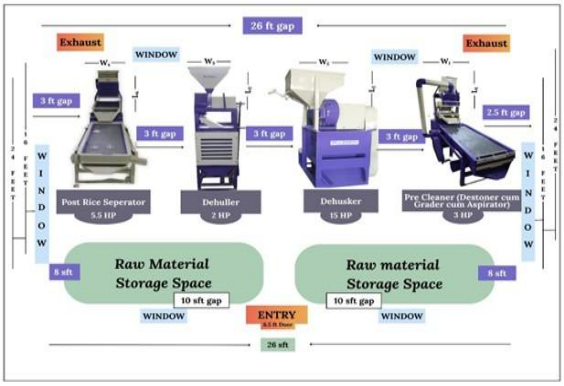

Figure 3. Optimal Layout Design for Millet Primary Processing Units

Primary Processing:

Machine	Function	Horsepower (HP)	Recommended space (LxWxH ft)
Pre-Cleaner (Destoner cum Grader cum Aspirator)	Removes dust, stones, and foreign matter	3 HP	10 × 4 × 7.2
Dehusker	Removes husks from millet grains	15 HP	5 × 3 × 6
Dehuller	Separates finer layers for clean grain	2 HP	5 × 3 × 6
Post-Rice Separator / Polisher	Polishes and improves final grain quality	5.5 HP	14 × 3.5 × 7.2

Secondary processing:

Machine	Function	Recommended space (LxWxH ft)
Pulverizer	Converts grain into flour	2 × 1.2 × 3.7
Chakki Mill	Traditional flour milling	2 × 2.4 × 3.1
Vibro Sifter	Uniform separation of flour particles	3 × 3 × 10
Blender	Mixes flour or malt powder uniformly	3.7 × 1.6 × 2.8

Sealer	Seals pouches or packets	2.1 × 1 × 1.1
Rawa Maker	Produces millet rawa / semolina	3.8 × 1.1 × 2.8
Vacuum Packing	Increases shelf life of millet products	2.2 × 2.4 × 2.7

Infrastructure Requirements:

Component	Requirement
Building Space	Minimum 24 × 52 ft for primary processing line
Entry Door	6.5 ft wide for easy movement of material
Storage Space	At least 8–10 ft wide sections for raw and finished goods
Spacing Between Machines	2.5–3 ft gap for safety and maintenance
Ventilation	Adequate windows and exhausts to minimize dust and maintain airflow
Power Supply	Stable connection for 2–15 HP machines, with generator/solar backup recommended

Machinery Vendors:

Vendor name	Location	Contact number	Specialization
Bhavani industries	Gumbaz Road, Ganjam (P.0) Srirangapatna, karnataka	8236 252900	Destoner, Polisher, Dehuller
Nabhitha Engineering Pvt. LTD	Nadargul, Hyderabad	9966533396	Destoner, Dehusker, Polisher, Dehuller
Perfura technologies pvt ltd	Coimbatore, TN	9894850009	Millet dehullers, Grader sum aspirator, Polisher, Pulverizer, Flour sifter
Agromech Engineers	Coimbatore, TN	9791766406	Destoner, Dehuller
Vishra agro sales	Virudhunagar, TN	63790 84691	Millet Dehuller, dehusker, Destoner cum grader
AVM engineering industries	Salem, Tamil Nadu	9443633131	Destoner cum grader cum aspirator, Pulverizer, Polisher
Borne technologies pvt.ltd	Dindigul, TamilNadu,	7339222802	Destoner, Dehuller
Victor agro sales	Salem, Tamil Nadu	95007 27272	Grader, Pulverizer
Sree valsa engineering company	Coimbatore, TN	08048957982	Destoner, Pulverizer, Dehuller
Premium vijimech pvt. Ltd	Ahmedabad, Gujarat	9712987467	Pulverizer, Sifter

CONCLUSION:

Millet primary processing units are pivotal in transforming raw millets into high-quality, market-ready grains, enabling farmers and farmer producer organizations to realize better incomes and market access. By integrating well-designed machinery layouts, suitable infrastructure, and proper workflow, these units reduce post-harvest losses, enhance food safety, and extend the shelf life of millets. Moreover, they act as catalysts for rural entrepreneurship, value addition, and sustainable agricultural development. Establishing scalable and efficient primary processing facilities not only empowers rural communities but also supports India's broader goals of nutrition security, ecological resilience, and climate-smart agriculture. As millets gain momentum in health-conscious and sustainable food markets, strong processing infrastructure will be critical to unlocking their full potential.

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