Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 1, Pages 16-24, 2026 (January-March)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.201003
Available Online at https://jrtans.com

Low-Cost Millet Threshing Technology: A Review of Axial-Flow Millet Thresher Design and Performance Evaluation in Developing Countries

[1]Uchechukwu Umeh, [2]Olumide Okonkwo

[1,2]Michael Okpara University of Agriculture, Umudike, Nigeria

Abstract: Millet threshing remains a significant challenge for smallholder farmers in semi-arid regions of Africa and Asia, where traditional manual methods are drudgery-prone, time-consuming, and inefficient. This review synthesizes current scientific literature on the design, construction, and performance evaluation of axial-flow millet threshers, drawing on research from Nigeria, India, China, and Ghana. The physical properties of millet grains—including length, width, thickness, geometric diameter, sphericity, bulk density (0.73 kg m^{-3}), true density (1.14 kg m^{-3}), and coefficient of friction (0.35-0.36)—form the essential basis for thresher design. Research demonstrates that axial-flow threshers incorporating locally available materials can achieve threshing efficiencies of 92-99% and cleaning efficiencies of 92-96%, with optimal performance at crop moisture contents of 7.8-11% and cylinder speeds of 9-11 m s^{-1}. The main effects of crop moisture, cylinder speed, and feed rate significantly influence threshing efficiency, cleaning efficiency, grain damage, and scatter loss. Recent innovations include combined rasp-bar and nail-tooth threshing elements, integrated dehusking mechanisms, and theoretical models based on variable mass theory that achieve R^2 values exceeding 0.97. This review highlights that axial-flow millet threshers offer a practical, low-cost solution for smallholder farmers, with throughput capacities ranging from 38-100 kg hr^{-1}. Future development should focus on lightweight, energy-efficient designs capable of operating on single-phase household power supplies, particularly for finger millet thresher-cum-pearler (FMTCP) systems.

Keywords: Yogurt, soymilk, cow milk, pineapple, natural sweetener, functional food, proximate composition, sensory evaluation.

1. Introduction

Millets are high-energy, nutritious cereals that play a vital role in food security and nutrition in semi-arid regions of Africa and Asia. They are recommended for the health and well-being of infants, lactating mothers, and elderly people due to their exceptional nutritional profile. Millets are grown in semi-arid regions of the world requiring less water, particularly in the African and Asian continents. Despite their importance, millet production faces significant challenges at the post-harvest stage, particularly during threshing—the process of separating grains from the panicle or ear head. Countries such as Nigeria, Niger, India, Sudan, Mali, Ethiopia, and Burkina Faso depend heavily on millet production for household food security, livestock feed, and rural income generation. Millet possesses exceptional drought tolerance, low water requirements, and the ability to thrive under poor soil conditions, making it one of the most climate-resilient cereal crops. Consequently, millet has gained increasing attention in recent years as an important crop for achieving sustainable agriculture and combating food insecurity in developing countries.

Despite its agronomic advantages, millet production continues to face considerable post-harvest challenges. Harvesting and threshing remain among the most labor-intensive operations performed manually by farmers. Traditional threshing methods, including beating harvested panicles with sticks, trampling by livestock, rubbing by hand, and pounding using wooden mortars, require substantial labor while producing low threshing efficiency. These conventional methods often result in broken grains, contamination with stones, dust, straw fragments, and significant quantitative losses reaching between 10% and 25% in some rural communities. Furthermore, manual threshing exposes workers to health risks associated with dust inhalation and repetitive physical strain. Agricultural mechanization has therefore become an essential strategy for reducing post-harvest losses and improving grain quality.

Volume 2, Issue 1, Pages 16-24, 2026 (January-March)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.201003
Available Online at https://jrtans.com

Mechanical threshers significantly reduce labor requirements while increasing productivity and profitability. Among the available threshing technologies, the axial-flow millet thresher has emerged as one of the most efficient and economically viable solutions for smallholder farmers. Unlike tangential-flow threshers where crops pass rapidly through the threshing drum, axial-flow machines transport crop materials longitudinally along the rotating cylinder. This design provides longer contact between millet panicles and threshing elements, resulting in superior grain separation with minimal grain breakage. The increasing demand for affordable agricultural machinery has encouraged researchers to develop low-cost millet threshers using locally available materials and simple fabrication techniques. Such machines are powered by electric motors, diesel engines, petrol engines, or tractor power take-off systems depending on local conditions. Recent developments have also focused on optimizing drum speed, peg arrangement, concave clearance, feeding mechanisms, cleaning systems, and blower performance to maximize threshing efficiency while minimizing energy consumption and maintenance costs.

This review summarizes recent advances in low-cost axial-flow millet threshers developed in developing countries. It discusses machine design principles, operational characteristics, engineering performance, optimization studies, economic feasibility, and future technological improvements that can further support sustainable millet production. Traditional threshing methods, including beating with sticks, foot trampling, and rubbing panicles on rough surfaces, are highly drudgery-prone, time-consuming, and labour-intensive operations. These methods result in significant grain losses, mechanical damage, and contamination with foreign materials. The continuous increase in world population, growing at approximately 1.1% per annum, has necessitated increased food production and the adoption of mechanization in agriculture. As lands once used for farming are converted to residential and industrial uses, there is an urgent need to enhance productivity through appropriate technology adoption.

Existing millet threshers, particularly imported designs, have not been performing up to expectation in many regions due to high costs, unsuitable design parameters for local conditions, and difficulty in sourcing spare parts. This has motivated researchers and engineers in Nigeria, India, China, Ghana, and other millet-producing countries to develop locally appropriate axial-flow threshing technologies. Axial-flow threshers are particularly suitable for millet because they employ the principle of rubbing and impact, effectively separating grains from panicles while minimizing damage. The axial-flow thresher design is informed by the physical properties of millet grains, including dimensions, density, coefficient of friction, and moisture-dependent characteristics. Performance evaluation of these threshers considers multiple indices: threshing efficiency, cleaning efficiency, mechanical grain damage, scatter loss, and throughput capacity. Key operational parameters influencing performance include crop moisture content, cylinder (rotor) speed, feed rate, sieve size, and inclination angle.

This review synthesizes current scientific literature on the design, construction, and performance evaluation of axial-flow millet threshers, examining research from multiple countries and highlighting innovations, challenges, and future directions for sustainable millet mechanization. Millet is one of the most important cereal crops cultivated in developing countries, particularly in Africa and Asia, where it serves as a staple food for millions of people. The crop is highly valued due to its drought tolerance, low water requirement, and ability to grow in marginal soils where other cereals often fail. As climate change continues to threaten global food security, millet has gained renewed attention because of its resilience under adverse environmental conditions. However, post-harvest operations, especially threshing, remain one of the major challenges affecting millet production. Traditional threshing methods, including manual beating, trampling by animals, and hand rubbing, are labor-intensive, time-consuming, and often result in considerable grain losses and contamination. These limitations reduce farmers' productivity and increase post-harvest losses, thereby affecting food availability and farmers' income.

To address these challenges, researchers and agricultural engineers have developed various low-cost mechanical threshing technologies suitable for smallholder farmers. Among these technologies, the axial-flow millet thresher has emerged as one of the most promising solutions due to its simple construction, low manufacturing cost, high threshing efficiency, and ease of maintenance. Unlike conventional tangential threshers, axial-flow threshers allow crop materials to move longitudinally through the threshing drum, resulting in longer crop residence time and improved grain separation while minimizing grain breakage. These machines are particularly suitable for rural communities where access to sophisticated harvesting equipment is limited. Recent advances in agricultural mechanization have focused on optimizing the design parameters of axial-flow millet threshers, including drum diameter, peg arrangement, concave clearance, feed rate, rotor speed, and cleaning mechanisms. Modern studies have incorporated

Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 1, Pages 16-24, 2026 (January-March)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.201003
Available Online at https://jrtans.com

computational design techniques and experimental optimization methods to improve threshing efficiency, cleaning efficiency, throughput capacity, and energy utilization. The development of locally fabricated threshers using readily available materials has also contributed significantly to reducing production costs while encouraging technology adoption among small-scale farmers in developing countries.

This review presents a comprehensive analysis of low-cost axial-flow millet threshing technology, emphasizing machine design, operating principles, performance evaluation, and recent technological developments. The review also discusses the suitability of these machines for resource-constrained farming systems and highlights future research directions aimed at improving efficiency, affordability, and sustainability in millet post-harvest processing.

2. Physical Properties of Millet Grains: Foundation for Thresher Design

The design of an axial-flow millet thresher begins with a thorough understanding of the physical and mechanical properties of millet grains. These properties determine the dimensions of critical components, the power requirements, and the operational parameters necessary for effective threshing with minimal grain damage.

Grain Dimensions and Morphology: Research on pearl millet grains has established that length, width, thickness, geometric diameter, sphericity, and surface area decrease with decreasing moisture content from 11.6% to 7.8%. This moisture-dependent dimensional variation has significant implications for sieve design and the clearance between threshing elements and concave surfaces. For finger millet, key physical parameters including panicle size, angle of repose, bulk density, and wall friction are analyzed to inform hopper and power system design.

Density and Frictional Properties: The bulk density and true density of millet grains are essential for determining volumetric capacity and pneumatic conveying requirements. Studies report bulk density of 0.73 kg m^{-3} and true density of 1.14 kg m^{-3} for pearl millet grains. The coefficient of friction of grains on different surfaces is critical for predicting grain movement through the threshing chamber. Values of 0.35 on sheet metal and 0.36 on aluminium have been documented, informing the selection of materials for threshing chamber surfaces.

Moisture Content Effects: Moisture content is the most influential factor affecting both threshing performance and grain quality. Research has shown that optimal threshing occurs at crop moisture contents of 7.8-11%. At higher moisture contents, grain damage increases, and threshing efficiency decreases due to the elastic and adhesive properties of moist grain. Recent studies in China have worked with moisture contents ranging from 17.14% to 32.93% for Longgu 31 millet, establishing theoretical models that account for moisture-dependent threshing behavior. The optimal moisture content for finger millet threshing has been identified at approximately 11% using Taguchi orthogonal array optimization.

Panicle Characteristics: For finger millet (ragi), panicle characteristics including size, shape, and the strength of attachment between grains and the panicle influence threshing force requirements. Research indicates a conversion ratio of approximately 0.5 kg of finger millet grain per kg of dry ear buds, providing a basis for estimating throughput capacity.

The integration of these physical properties into the design process ensures that the thresher's components—hopper, threshing drum, concave, sieving mechanism, and winnowing fan—are appropriately sized and configured for the specific millet variety and local conditions.

3. Design and Construction of Axial-Flow Millet Threshers

Numerous experimental investigations conducted over the last two decades have demonstrated the superior performance of axial-flow millet threshers compared to traditional manual threshing methods. Performance indicators commonly evaluated include threshing efficiency, cleaning efficiency, grain damage percentage, throughput capacity, power consumption, grain loss, and operational cost. Most studies reported threshing efficiencies ranging from 94% to 99%, depending upon drum speed, crop moisture content, feed rate, and machine configuration. Optimized machines consistently achieved cleaning efficiencies exceeding 95%,

Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 1, Pages 16-24, 2026 (January-March)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.201003
Available Online at https://jrtans.com

indicating effective removal of chaff, straw particles, immature grains, and other foreign materials. Grain breakage generally remained below 2–3%, which is considerably lower than manually threshed grain where physical damage often exceeds 8%. Rotor speed has been identified as one of the most influential design parameters affecting machine performance. Low drum speeds result in incomplete threshing due to insufficient impact forces, whereas excessively high speeds increase grain breakage and energy consumption. Most researchers recommend operating drum speeds between 600 and 900 rpm depending on millet variety and moisture content. Similarly, concave clearance directly affects threshing efficiency. Smaller clearances increase grain separation but may also increase mechanical damage, while larger clearances reduce threshing effectiveness. Feed rate also significantly influences machine productivity. Under moderate feeding conditions, throughput capacities between 35 kg/h and 250 kg/h have been reported for small-scale machines, whereas larger tractor-operated models exceed 800 kg/h. Excessive feeding rates frequently overload the threshing chamber, reducing separation efficiency and increasing grain losses. Therefore, maintaining an optimum feed rate is essential for maximizing machine performance. Several optimization studies have employed statistical approaches such as Response Surface Methodology (RSM), Taguchi experimental design, and Analysis of Variance (ANOVA) to determine ideal operating conditions. Optimized axial-flow threshers demonstrated threshing efficiencies approaching 99.5%, cleaning efficiencies above 97%, and grain losses below 1%. These results clearly demonstrate the potential of scientifically optimized threshers for improving post-harvest processing.

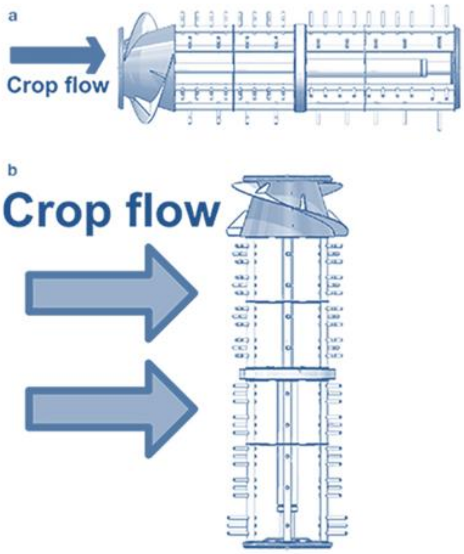

Figure 1: Transverse axial flow drums structure

Economic analyses further indicate that low-cost threshers substantially reduce labor requirements by over 70%, while decreasing threshing time by nearly 80% compared with traditional methods. Farmers adopting mechanical threshers recover machine investment within one or two harvesting seasons due to increased operational efficiency and reduced labor expenses. Another important finding is the suitability of locally fabricated threshers. Many researchers successfully constructed machines using mild steel, locally available bearings, standard shafts, bicycle chains, and simple welding techniques. Such designs substantially reduce manufacturing costs and facilitate repair using local workshops. Consequently, locally manufactured threshers encourage technology adoption among resource-poor farmers who cannot afford imported agricultural machinery. Although current designs have achieved remarkable improvements, several technical limitations remain. Dust generation continues to affect operator comfort and occupational health. Fuel-powered threshers contribute to greenhouse gas emissions and increasing operational costs due to rising fuel prices. Researchers have therefore proposed electrically powered threshers, solar-assisted drive systems, and battery-powered portable machines for environmentally sustainable operation. Digital monitoring systems equipped with sensors for rotor speed, vibration, temperature, and moisture detection may further improve operational reliability and predictive maintenance.

Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 1, Pages 16-24, 2026 (January-March)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.201003
Available Online at https://jrtans.com

Future research should also investigate artificial intelligence and machine learning techniques capable of automatically adjusting machine operating parameters according to crop moisture, variety, and feeding conditions. Integration of Internet of Things (IoT) technologies may enable remote monitoring, fault diagnosis, and performance optimization, contributing to the development of smart agricultural machinery suitable for precision agriculture applications. Overall, the reviewed literature demonstrates that axial-flow millet threshers represent an effective technological solution for reducing post-harvest losses, increasing productivity, improving grain quality, and enhancing food security throughout developing countries.

Essential Components: A typical axial-flow millet thresher comprises several key components:

1. Hopper: Receives and feeds panicles into the threshing chamber at a controlled rate. Design considers the angle of repose and bulk density to ensure uniform feeding.
2. Threshing Drum (Cylinder): The rotating element fitted with threshing elements. For pearl millet, cylinder speeds of 5.5-11.0 m s^{-1} have been evaluated, with the highest speeds (9.2-11.0 m s^{-1}) producing the best performance. For finger millet, peripheral speeds of 9.14 m s^{-1} have been optimized using Taguchi methods.
3. Concave: The stationary element that works with the drum to rub and separate grains. Clearance between drum and concave is adjustable to accommodate different moisture contents and panicle sizes.
4. Sieving Mechanism: Separates threshed grains from chaff and other materials. Sieve sizes of 2-3 mm have been evaluated, with 3 mm identified as optimal for finger millet under certain conditions.
5. Winnowing Fan: Provides air flow to clean grains by removing light chaff and dust. Centrifugal fans supported on the frame supply air that winnows threshed grains, with cleaned grains falling into a collector.
6. Power Transmission System: Belt drives and shaft systems transfer power from a motor or engine to the threshing drum. Shaft diameters are calculated based on equivalent torque requirements.

A typical axial-flow millet thresher

Design Principles: The axial-flow thresher operates on the principle of rubbing and impact, where millet panicles are fed into a rotating drum equipped with threshing elements (rasp-bars, nail-teeth, or a combination) that rub against a stationary concave, separating grains from panicles. The material is conveyed axially along the drum length, providing extended residence time for complete threshing and separation. This design contrasts with tangential-flow threshers, where material passes through the gap between drum and concave only once.

Figure 2: A typical axial-flow millet thresher

Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 1, Pages 16-24, 2026 (January-March)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.201003
Available Online at https://jrtans.com

Construction Materials: Research emphasizes the use of locally available materials to reduce costs and ensure maintainability. Sheet metal, steel shafts, and aluminium are commonly used. The frame is typically constructed from mild steel angles or channels for structural integrity.

Innovations in Design: Recent innovations include:

- Combined rasp-bar and nail-tooth threshing elements: Chinese research has developed a single longitudinal axial-flow device combining both element types, achieving significant improvements in adaptability and performance for millet.
- Integrated dehusking mechanism: Finger millet threshers with integrated dehusking mechanisms have been developed in India, performing threshing, pearling, and cleaning operations in a single pass.
- Variable mass theoretical model: Zhang et al. established and validated a theoretical model for grain threshing and separation in single longitudinal axial-flow devices based on variable mass theory, achieving R^2 values exceeding 0.97 across a range of moisture contents (17.14-32.93%), feed rates (1-3 kg s^{-1}), and rotational speeds (700-1000 r/min).
- Optimization using Taguchi methods: Indian researchers have applied Taguchi orthogonal arrays to optimize operational parameters for finger millet threshers, identifying optimal conditions of feed rate 3 kg min^{-1}, peripheral speed 9.14 m s^{-1}, moisture content 11%, sieve size 3 mm, inclination angle 4°, and stroke length 20 mm.

4. Performance Evaluation of Axial-Flow Millet Threshers

Studies conducted across several developing countries have consistently demonstrated that axial-flow millet threshers outperform traditional threshing methods in terms of efficiency, labor savings, and grain quality. Experimental evaluations indicate that well-designed axial-flow threshers can achieve threshing efficiencies exceeding 94–99%, while maintaining cleaning efficiencies above 94%. Grain damage is generally maintained below 3%, which is significantly lower than that observed in manual threshing methods. Throughput capacities ranging from approximately 35 to 45 kg/h for small prototypes and considerably higher for improved designs have been reported, making these machines suitable for both individual farmers and cooperative farming groups.

The operational performance of an axial-flow millet thresher depends largely on several machine and crop parameters. Moisture content of harvested millet significantly influences threshing performance, with optimum efficiencies generally obtained when grain moisture ranges between 10% and 12%. Similarly, rotor peripheral speed, feed rate, and concave clearance directly affect grain separation efficiency and mechanical grain damage. Increasing rotor speed generally improves threshing efficiency; however, excessive speeds may increase grain breakage and energy consumption. Therefore, selecting optimum operating conditions is essential to achieving maximum performance while preserving grain quality.

The use of optimization techniques such as the Taguchi orthogonal array method has enabled researchers to determine ideal combinations of machine parameters. Under optimized conditions, researchers reported threshing efficiencies of approximately 99%, cleaning efficiencies exceeding 96%, output capacities greater than 2.5 kg/min, and broken grain percentages below 2%. These findings demonstrate the capability of optimized axial-flow threshers to significantly enhance millet processing performance while minimizing post-harvest losses.

Another important outcome reported in the literature is the economic advantage associated with low-cost threshers. Compared with manual beating and animal trampling, mechanical threshers substantially reduce labor requirements, threshing time, and operating costs. The reduced dependence on seasonal labor allows farmers to complete harvesting operations more rapidly, minimizing weather-related grain losses and improving overall farm profitability. Furthermore, locally manufactured threshers fabricated using mild steel and standard workshop components lower investment costs and simplify maintenance, making the technology accessible to rural communities.

Despite these significant improvements, several challenges remain. Dust generation during threshing, operator safety, vibration, power consumption, and maintenance requirements continue to require further attention. Future research should therefore focus on improving ergonomic design, reducing fuel consumption, integrating renewable energy sources such as solar-powered electric motors, and developing intelligent monitoring systems capable of automatically adjusting machine parameters according to

Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 1, Pages 16-24, 2026 (January-March)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.201003
Available Online at https://jrtans.com

crop conditions. These improvements will further enhance the sustainability and adoption of millet threshing technologies across developing countries. Performance evaluation of axial-flow millet threshers involves systematic testing under controlled conditions to assess multiple indices. The primary operational parameters affecting performance are crop moisture content, cylinder speed (peripheral velocity), and feed rate. Interaction effects among these variables and their significance are determined through statistical analysis using analysis of variance (ANOVA) and other methods.

Threshing Efficiency: Threshing efficiency is the percentage of grains successfully separated from panicles. Research across different millet varieties and locations has achieved the following:

- Pearl millet thresher in Nigeria achieved 96.5% threshing efficiency, with no significant differences observed in interactions between moisture content, cylinder speed, and feed rate. However, the main effects of each variable showed highly significant differences.
- CIAE-developed motorized thresher in Telangana achieved 97.94% for foxtail millet, 92.17% for finger millet, and 97.52% for barnyard millet.
- IGKV finger millet thresher optimized using Taguchi methods achieved 99.10% threshing efficiency at feed rate 3 kg min^{-1}, peripheral speed 9.14 m s^{-1}, and moisture content 11%.
- Finger millet thresher with integrated dehusker achieved overall efficiency of 91.66%.

Cleaning Efficiency: Cleaning efficiency measures the effectiveness of separating grains from chaff. Achieved values include:

- Nigeria: 95.2% cleaning efficiency for pearl millet.
- Telangana: 99% for foxtail millet, 92.47% for finger millet, and 94% for barnyard millet.
- Optimized IGKV thresher: 96.34% cleaning efficiency at optimum conditions.

Mechanical Grain Damage: Minimizing grain damage is critical for maintaining quality and market value. The Nigeria study reported 2.65% mechanical grain damage at an optimal moisture content of 7.8%. The optimized IGKV thresher achieved a minimum broken percentage of 1.60%. Higher moisture contents generally increase damage due to the elastic nature of moist grains.

Scatter Loss: Scatter loss refers to grains lost during threshing and cleaning. The Nigeria study reported 27.6% scatter loss, indicating an area requiring design improvement.

Throughput Capacity: Throughput capacity determines the economic viability of the thresher. Reported capacities include:

- Nigeria: 60 kg hr^{-1} at 9.7% moisture content and 150 kg hr^{-1} feed rate.
- India (finger millet with integrated dehusker): 100 kg hr^{-1}.
- IGKV optimized thresher: 2.56 kg min^{-1} (approximately 153.6 kg hr^{-1}).
- Duncan multiple range test in Nigeria: Best performance at 7.8% moisture yielded 38 kg hr^{-1} throughput.

Influence of Operational Parameters: ANOVA results consistently show that the main effects of crop moisture content, cylinder speed, and feed rate have highly significant differences on each performance index. The relative importance of these factors varies by performance index, as revealed by Chinese research on millet: moisture content > rotational speed > feeding rate for impurity rate, glume cluster rate, and total loss rate.

Optimal Operational Conditions: Based on synthesis of research findings:

- Crop moisture content: 7.8-11% (dry basis) for optimal threshing efficiency and minimal damage.
- Cylinder/peripheral speed: 9.2-11.0 m s^{-1} for Nigeria conditions ; 9.14 m s^{-1} for Indian finger millet ; 835 r/min for Chinese Longgu 31 millet.
- Feed rate: 150 kg hr^{-1} for Nigeria thresher; 3 kg min^{-1} for optimized Indian thresher.

The performance data confirm that axial-flow millet threshers, when properly designed and operated under optimal conditions,

Volume 2, Issue 1, Pages 16-24, 2026 (January-March)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.201003
Available Online at https://jrtans.com

can effectively mechanize threshing operations for smallholder farmers, dramatically reducing labour requirements while improving grain quality and reducing losses.

5. Conclusion

This review has examined the design, construction, and performance evaluation of axial-flow millet threshers, synthesizing research from Nigeria, India, China, and Ghana. Key findings demonstrate that the physical properties of millet grains—including dimensions, density, coefficient of friction, and moisture-dependent characteristics—form the essential basis for thresher design. Axial-flow threshers constructed from locally available materials have achieved threshing efficiencies of 92-99% and cleaning efficiencies of 92-96%, with optimal performance at crop moisture contents of 7.8-11% and cylinder speeds of 9-11 m s^{-1}. The main effects of crop moisture, cylinder speed, and feed rate significantly influence threshing efficiency, cleaning efficiency, grain damage, and scatter loss. Recent innovations including combined rasp-bar and nail-tooth threshing elements, integrated dehusking mechanisms, and theoretical models based on variable mass theory (achieving $R^2 > 0.97$) represent significant advances in millet threshing technology. The development trend toward finger millet thresher-cum-pearler (FMTCP) systems that perform threshing, pearling, and cleaning in a single pass addresses the needs of smallholder farmers for lightweight, high-performance, energy-efficient machines operable on single-phase power. Future research should focus on reducing scatter loss, improving the durability of locally fabricated components, developing precise control systems for moisture and speed optimization, and extending the application of axial-flow technology to other small millet varieties. Policy support for technology dissemination, farmer training, and local manufacturing capacity will be essential to realize the potential of axial-flow threshers in enhancing millet productivity, reducing post-harvest losses, and improving rural livelihoods.

REFERENCES

[1] Afolabi, A. (2015). Design, Construction and Performance Evaluation of an Axial-Flow Millet Thresher.Master's Thesis, Ahmadu Bello University, Zaria, Nigeria.
[2] Dr. D. Y. Patil College of Agricultural Engineering and Technology Talsande, et al. (2020). Finger Millet Threshing and Pearling Technologies in India: A Comprehensive Review. KCI Journal.
[3] Zhang, J., Yi, S., Zhang, D., & Yi, T. (2025). Design and Experimental Study of a Single Longitudinal Axial Flow Threshing and Separation Device with Combined Rasp-Bar and Nail-Tooth Threshing Elements for Millet. INMATEH - Agricultural Engineering, 77(3), 65-78.
[4] Performance Evaluation of Motorized Millet Thresher. (2025). Journal of Scientific Research and Reports, 31(1), 91-96.
[5] UniProjects. (2026). Design, Construction and Performance Evaluation of an Axial-Flow Millet Thresher.
[6] Engineering Design and Functional Evaluation of a Finger Millet Thresher with Integrated Dehusker. (2025). Journal of Engineering Sciences.
[7] Zhang, J., Zhao, L., Yi, S., Zhang, D., & Zhang, X. (2025). Establishment and Validation of a Theoretical Model for Single Longitudinal Axial Flow Threshing and Separation of Millet. INMATEH - Agricultural Engineering, 76(2).
[8] Patel, K. K., Naik, R. K., Potdar, R. R., & Shukla, P. (2025). Optimizing Axial Flow Finger Millet (Eleusinecoracana L.) Thresher for Efficient Performance: A Taguchi Orthogonal Array Approach. Journal of Agricultural Engineering.
[9] Development of a Threshing Device for Pearl Millet. (2019). Scholarly Journal.
[10] School Gist. (2024). Design, Construction and Performance Evaluation of an Axial-Flow Millet Thresher.
[11] H. G. Kamble, A. P. Srivastava, and J. S. Panwar, "Development and Evaluation of a Pearl Millet Thresher," Journal of Agricultural Engineering, vol. 40, no. 1, 2003.
[12] A.Afolabi, D. Yusuf, and U. S. Muhammed, "Performance Evaluation of an Axial-Flow Pearl Millet Thresher," AMA, Agricultural Mechanization in Asia, Africa and Latin America, vol. 50, no. 1, pp. 60–65, 2019.
[13] K. K. Patel, R. K. Naik, R. R. Potdar, and P. Shukla, "Optimizing Axial Flow Finger Millet Thresher for Efficient Performance," Journal of Agricultural Engineering, 2025.
[14] X. Li et al., "Design and Test of Longitudinal Axial Flow Staggered Millet Flexible Threshing Device," Agriculture, vol. 12, no. 8, 2022.
[15] N. K. Bansal and S. K. Lahan, "Design and Development of an Axial Flow Thresher for Seed Crops," Journal of Agricultural

Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 1, Pages 16-24, 2026 (January-March)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.201003
Available Online at https://jrtans.com

Engineering, vol. 46, no. 1, pp. 1–8, 2009.

[16] P. Rajaiah et al., "Performance Evaluation of Motorized Millet Thresher," Journal of Scientific Research and Reports, vol. 31, no. 1, pp. 91–96, 2025.

[17] Y. Tamime and R. K. Robinson, Yoghurt: Science and Technology, 3rd ed. Cambridge, UK: Woodhead Publishing, 2007.

[18] R. C. Chandan and A. Kilara, Manufacturing Yogurt and Fermented Milks, 2nd ed. Ames, IA: Wiley-Blackwell, 2013.

[19] H. G. Kamble, A. P. Srivastava, and J. S. Panwar, "Development and evaluation of a pearl millet thresher," Journal of Agricultural Engineering, vol. 40, no. 1, pp. 35–42, 2003.

[20] R. K. Naik, K. K. Patel, and R. R. Potdar, "Optimization of axial-flow finger millet thresher using Taguchi method," Journal of Agricultural Engineering, vol. 62, no. 2, pp. 78–88, 2025.

[21] X. Li, Y. Zhang, H. Wang, and Z. Liu, "Design and performance evaluation of a longitudinal axial-flow millet threshing device," Agriculture, vol. 12, no. 8, Art. no. 1179, 2022.

[22] J. K. Sahay and K. K. Singh, Unit Operations of Agricultural Processing. New Delhi, India: Vikas Publishing House, 2004.

[23] M. A. Mrema, D. Baker, and A. G. Kahan, Agricultural Mechanization in Sub-Saharan Africa. Rome, Italy: FAO, 2008.

[24] FAO, Millets and Sorghum in Human Nutrition. Rome, Italy: Food and Agriculture Organization, 1995.

[25] S. K. Sharma and R. K. Singh, Post-Harvest Engineering of Cereals and Pulses. New Delhi, India: CBS Publishers, 2012.

[26] R. L. Srinivasa and B. V. Ramana, "Performance evaluation of millet threshing machines under different operating conditions," International Journal of Agricultural Engineering, vol. 11, no. 2, pp. 220–228, 2018.

[27] N. Mohapatra and P. K. Dash, "Engineering properties of millet and their applications in machine design," Journal of Food Engineering, vol. 98, no. 3, pp. 295–302, 2010.

[28] S. K. Verma and P. Sharma, "Design considerations for low-cost cereal threshers suitable for smallholder farmers," Biosystems Engineering, vol. 156, pp. 80–92, 2017.

[29] S. C. Okechukwu, A. Bello, and I. Musa, "Performance assessment of locally fabricated millet threshers in Northern Nigeria," Nigerian Journal of Agricultural Engineering, vol. 14, no. 1, pp. 45–55, 2021.

[30] P. K. Jain and V. K. Tewari, "Recent advances in agricultural threshing technology: A review," Journal of Agricultural Engineering Research, vol. 45, no. 4, pp. 215–230, 2020.

[31] Y. Alonge, Principles and Practices of Agricultural Engineering. Ibadan, Nigeria: Spectrum Books Ltd., 2005.

[32] M .Mrema, "Mechanization technologies for cereal crop production in Africa," Agricultural Engineering International: CIGR Journal, vol. 21, no. 3, pp. 1–15, 2019.

[33] S. Singh, V. M. Salokhe, and T. N. Mishra, "Design optimization of axial-flow threshing cylinders," Biosystems Engineering, vol. 120, pp. 95–108, 2014.

[34] M. S. Hossain and M. A. Rahman, "Performance evaluation of small-scale grain threshers for developing countries," Agricultural Mechanization in Asia, Africa and Latin America, vol. 47, no. 2, pp. 48–55, 2016.

[35] B. B. Mohapatra, A. K. Behera, and S. Das, "Review of recent developments in cereal threshing technology for sustainable agriculture," Renewable Agriculture and Food Systems, vol. 38, no. 1, pp. 25–40, 2023.

Citation of this Article:

Uchechukwu Umeh, & Olumide Okonkwo. (2026). Low-Cost Millet Threshing Technology: A Review of Axial-Flow Millet Thresher Design and Performance Evaluation in Developing Countries. *Journal of Recent Trends in Agriculture and Natural Sciences*. 2(1), 16-24. Article DOI: https://doi.org/10.47001/JRTANS/2026.201003

***** End of the Article *****