RICE AND CASSAVA PROCESSING INNOVATIONS FOR GLOBAL FOOD SECURITY AND RURAL LIVELIHOODS IN NIGERIA.

EFFA, E. B.,[1] OCHAYI, E. I.,[2] AND ETIM, O. U.[3]
[1]Department Of Crop Science, Faculty Of Agriculture, University Of Calabar, Calabar
[2]Yaba College Of Technology, Yaba, Lagos State
[3]Department of Agricultural Extension and Rural Sociology, University of Calabar, Calabar
Corresponding author: emmaeffa@yahoo.com

***Abstract**:*
This review explores Rice and Cassava processing innovations for global food security and rural livelihoods in Nigeria. The objectives of the study were to; examine recent advancements in rice processing technologies in Nigeria, assess recent advancements in cassava processing technologies in Nigeria and analyze innovations in rice and cassava storage and their implications for food security and rural livelihoods. The review of literature highlighted Innovations in Milling and Quality Controlsuch as Satake and Zaccaria, which show varying results depending on rice cultivar and moisture content. Also, the integration of Artificial Intelligence (AI) and Machine Learning (ML) is transforming rice quality prediction. Hybrid deep learning models, supported by Explainable AI (XAI) methods like SHAP and Grad-CAM, have achieved remarkable accuracy, outperforming traditional architectures in classifying rice grain quality. On Mechanization and Efficiency Improvements, Grating machines demonstrate efficiencies ranging from 91.56% to 97% and capacities between 60–500 kg/h. Flash dryer systems also mark a major innovation in cassava processing, significantly improving food safety and product quality during the drying of starch and flour. On Strategies for Post-Harvest Loss Reduction, the study reviewed that farmers and processors have adopted a variety of technologies to reduce PHL, including the use of mechanical driers, metallic silos, root choppers, shellers, specialized storage structures, and tarpaulins. The study concludes that widespread adoption of these technologies continues to be hindered by high costs, weak policy support, and the need for context-specific designs. The study recommends that strengthening market linkages, improving logistics, and encouraging value addition can create a more resilient and competitive rice and cassava value chain.

***Keywords:** Rice processing innovations, cassava processing innovations, global food security, rural livelihoods, AI processing technologies.*

Introduction

Rice and cassava are two of the most important staple crops in Nigeria, serving as major sources of food and income for rural households. In recent years, technological advances in processing these crops have played a critical role in improving productivity, reducing post-harvest losses, and enhancing food security (Ajirotutu, Adeyemi, Ifechukwu, Iwuanyanwu, & Ohakawa, 2024). Rice milling, fortification, and parboiling innovations have not only improved grain quality but also increased market competitiveness, while mechanization has reduced drudgery and labor costs for smallholder farmers (Mausch, et al., 2020). For cassava, the introduction of modern equipment for starch extraction, gari processing, and high-quality cassava flour production has opened new market opportunities and supported agro-industrial development in Nigeria. These advancements are particularly significant in rural areas where traditional methods were previously labor-intensive and less efficient. Moreover, innovations in rice and cassava storage have further strengthened their contributions to global food security and rural livelihoods. Improved hermetic storage bags, silos, and cold storage technologies help minimize spoilage and pest infestation, thereby extending the shelf life of both rice and cassava products (Ochieng et al., 2018). Such developments have enhanced value chain efficiency and improved farmers' incomes, as crops can now be stored for longer periods and sold at favorable market prices. Thus, recent technological improvements in the processing and storage of rice and cassava are not only critical for meeting Nigeria's food demands but also for contributing to the broader agenda of global food security and sustainable rural development.

Projections show that cassava cultivation will continue to expand significantly in the coming decade, emphasizing its strategic role in feeding a growing population. However, both crops face major challenges linked to fragile soils, declining fertility, and climate change impacts. Post-harvest loss (PHL) is especially critical, with cassava roots deteriorating within two to three days of harvest, leading to losses as high as 30–40% in developing regions. Sub-Saharan Africa records some of the highest losses globally, worsening food insecurity. Recognizing these issues, the African Union set a target through the Malabo Declaration to reduce PHL by 50% by 2025. Minimizing these losses is central not only to achieving zero hunger but also to reducing waste and ensuring sustainable agricultural growth. Despite cassava's climate resilience, its future is threatened by long-term climate change, with projections suggesting a loss of half its optimally suitable land by 2100. This paradox highlights the need for proactive adaptation in breeding and cultivation strategies. Additionally, reducing PHL offers broader benefits by cutting greenhouse gas emissions and improving resource efficiency, given that rice production alone accounts for 16% of agricultural emissions. This report therefore reviews advancements in rice and cassava processing and storage technologies, evaluating their contributions to food security, economic opportunities, and climate change mitigation, while also outlining key challenges and areas for future research.

Despite the technological progress in rice and cassava processing, several challenges continue to limit their full potential in ensuring food security and sustainable livelihoods in Nigeria. Many rural farmers still rely on outdated and inefficient processing methods due to limited access to modern technologies, lack of technical know-how, and inadequate infrastructure (Chikezie, Ogbuagu, & Eze, 2023). As a result, significant portions of rice and cassava harvests are lost annually to poor handling, inefficient processing, and post-harvest wastage. These inefficiencies reduce the availability of food and undermine Nigeria's efforts to achieve self-sufficiency in staple crop production. Furthermore, storage innovations remain underutilized, especially in rural areas where smallholder farmers face constraints such as high costs of improved storage systems, poor extension support, and limited access to credit (Elegunde & Osagie, 2020). This gap between technological advancements and their practical adoption contributes to persistent food insecurity and rural poverty. Addressing these challenges requires a critical assessment of the recent advances in rice and cassava processing and storage, with a view to strengthening food systems and enhancing the livelihoods of rural communities in Nigeria.

Objectives of the Study

The study seeks to:

1. examine recent advancements in rice processing technologies in Nigeria.
2. assess recent advancements in cassava processing technologies in Nigeria.
3. analyze innovations in rice and cassava storage and their implications for food security and rural livelihoods.

Recent Advancements in Rice Processing Technologies
Innovations in Milling and Quality Control

Recent advancements in rice processing technologies have focused on optimizing milling and improving quality control to reduce losses and enhance consumer satisfaction. Milling optimization plays a key role in minimizing broken kernels and maximizing head rice yield, which is the primary indicator of milling quality. Beyond yield, rice quality also depends on nutritional content, sensory attributes, and functional performance in processed products. However, environmental stressors, particularly high nighttime temperatures during the grain fill stage, negatively affect grain quality by causing chalkiness, thinner kernels, and reduced milling yields. Meanwhile, laboratory milling assessment is evolving as the USDA phases out the McGill No. 2 mill, creating a need to recalibrate and standardize evaluations across modern laboratory mills, such as Satake and Zaccaria, which show varying results depending on rice cultivar and moisture content (USDA, 2019). In addition to hardware innovations, the integration of Artificial Intelligence (AI) and Machine Learning (ML) is transforming rice quality prediction. Hybrid deep learning models, supported by Explainable AI (XAI) methods like SHAP and Grad-CAM, have achieved remarkable accuracy, outperforming traditional architectures in classifying rice grain quality. These AI models incorporate advanced preprocessing techniques—such as image resizing, grayscale conversion, normalization, and data augmentation—to ensure robust performance and minimize over fitting. Their high sensitivity and specificity make them reliable for real-world applications, allowing for accurate identification of grain quality variations while reducing false predictions. Importantly, XAI tools enhance the interpretability of these models, making predictions more transparent and understandable to stakeholders. The shift from traditional milling assessments toward data-driven AI solutions marks a fundamental transformation in rice quality control. This transition not only ensures standardization across the industry but also provides resilience against climate-induced challenges like grain chalkiness. By addressing the "black box" problem of AI through XAI methods, stakeholders such as farmers, millers, and consumers can better trust and adopt these technologies. The blending of human expertise with AI-driven precision signals a move from reactive quality checks to proactive and predictive management, offering a more sustainable and technologically advanced pathway for the rice processing industry.

Table 6: Performance Comparison of AI/ML Models for Rice Quality Prediction

Model Name	Accuracy	Sensitivity	Specificity	F1-Score	Key Effect/Comment
Hybrid Model	≈0.95	Highest	Best	Highest	Robust, balances recall & precision
ResNet50	0.92	Good	Reasonably Good	Second Highest	High classification ability
MobileNetV2	Inferior to Hybrid/ResNet50	Better than CNN/VGG16	Reasonably Good	Better than CNN/VGG16	Improved over older models
VGG16	Below Average	Lags behind Hybrid/ResNet50	-	Worst (with CNN)	Less effective
CNN	Below Average	Poorest	Lowest	Worst (with VGG16)	Limited capacity, high false positives

Data compiled from Bhandari et al. (2022).

Sustainable Practices in Rice Milling

Sustainable practices in rice milling are increasingly important for reducing the environmental impacts of traditional milling, which consumes high levels of energy and water while generating significant waste. Modern milling technologies with energy-efficient motors and automation lower electricity use, while innovative waste valorization strategies transform by-products such as husks, bran, and dust into valuable resources like biofuels and biodegradable materials (International Rice Research Institute [IRRI], 2013). Projects such as the *Climate Resilient Innovations for Sustainable Production of Rice (CRISP Rice)* highlight how sustainability efforts can enhance both environmental quality and profitability by minimizing resource use and maximizing efficiency. Water use is another critical sustainability challenge in rice milling, as large volumes are consumed and discharged as wastewater during cleaning, soaking, and polishing. Best practices in wastewater management include starch and husk recovery systems, biological treatments like anaerobic digestion, and advanced techniques such as membrane filtration, which allow water recycling for non-potable uses (IRRI, 2013; Judd, 2011; Metcalf & Eddy, 2003). Cultivation methods like dry direct-seeding with drip irrigation (DDSR-D) have shown dramatic reductions in water consumption compared to conventional methods, alongside other water-saving approaches such as closed-loop recycling, rainwater harvesting, and heat recovery systems (Jian et al., 2020; IRRI, 2013). These practices not only conserve water but also lower pollution and reduce the demand for freshwater resources.

The integration of sustainable cultivation and milling practices yields broad environmental and economic benefits. DDSR-D, for example, has significantly reduced methane (CH_4) and carbon dioxide (CO_2) emissions, lowering the overall environmental footprint of rice production (Jian et al., 2020). The shift toward viewing by-products as inputs for a circular bioeconomy aligns economic incentives with sustainability by creating new income opportunities while reducing waste disposal costs (IRRI, 2013). Innovations in water conservation and precision agriculture underscore that resource efficiency enhances profitability, mitigates greenhouse gas emissions, and improves yields. Ultimately, a holistic, integrated approach to water, energy, and waste management is essential for achieving long-term sustainability in rice production.

Value-Added Rice Products

Advancements in rice processing increasingly emphasize the creation of value-added products that diversify markets, improve nutritional quality, and enhance economic returns. Rice's versatility enables its transformation into various products for both consumer and industrial uses. Rice flour, particularly gluten-free types, has gained popularity as a substitute for wheat flour in baking and food formulations, catering to dietary restrictions and consumer preferences. It is also processed into noodles, cakes, and pasta, while glutinous rice flours are commonly used in traditional Asian desserts and snacks.Parboiled rice represents another important category, where hydrothermal treatment prior to milling enhances nutritional value, increases milling yield by reducing breakage, and improves shelf life. This method also produces a firmer texture preferred in many regions (Bhattacharya, 2011). Similarly, rice bran, once considered a by-product, is now processed into rice bran oil—a cooking oil rich in antioxidants—and into protein concentrates for functional foods and supplements (Kumari et al., 2022). Rice husks also support circular economy practices, being converted into industrial silica or densified into biofuel briquettes (IRRI, 2013).Beyond these, fermentation technologies have enabled the production of rice-based alcoholic beverages such as sake and rice wine, as well as rice vinegar, which occupy niche but high-value markets (Wang et al., 2020). The development of ready-to-eat (RTE) rice products—including instant, pre-cooked, and flavored rice meals—further addresses the growing demand for convenience foods (Sahu et al., 2015). Collectively, these value-added innovations maximize the utility of rice, contribute to food security by reducing waste, and create new income opportunities for farmers and processors through diversification and access to premium markets.

Recent Advancements in Cassava Processing Technologies
Mechanization and Efficiency Improvements
Cassava processing has traditionally relied on small-scale, labor-intensive methods that are often inefficient and pose health risks due to improper handling. Given cassava's high perishability—roots spoil within 2–3 days after harvest—mechanization is essential to minimize post-harvest losses, improve product quality, and expand consumer access (Otoo et al., 2018; Sokoto & Abubakar, 2012). Beyond preservation, processing also serves as a detoxification step, removing harmful cyanogenic glucosides and enabling cassava to be safely transformed into diverse products for human consumption (Bradbury & Holloway, 1988). Although progress has been made, most cassava processing machines remain below optimal performance, with no technology achieving 100% efficiency and zero loss (Musa et al., 2020). Cassava Grating Machines such as; Motorized cassava grater (diesel- or electric-powered), Hammer-type or drum-type cassava grater, and Stainless-steel rotary cassava grater, are used for reducing cassava roots into mash during gari, fufu, and starch production. Cassava Peeling Machines also includes; Abrasive cassava peeler, Mechanical drum-type cassava peeler, and Rotary cassava peeling machine. These machines remove the cassava peel and reduce manual labor during primary processing. Cassava Slicing/Chipping Machines such as; Rotary cassava slicer, Cassava chipping machine, and Motorized cassava slicing machine, among others are used to cut cassava roots into chips or slices for drying, flour, and starch production. These machines collectively improve processing speed, reduce drudgery, and enhance efficiency in cassava primary processing systems, especially at small- and medium-scale levels. Grating machines, for example, demonstrate efficiencies ranging from 91.56% to 97% and capacities between 60–500 kg/h, though small-scale graters often have lower efficiency and contamination risks due to mild steel construction. Peeling machines also face limitations, with efficiency ranging from 70.45% to 95%, alongside significant flesh losses. Similarly, slicing machines often suffer from damaged slices and labor-intensive operation, particularly when built with low-grade materials (Musa et al., 2020). These challenges highlight the need for further redesign, use of food-grade materials, and integration of precision technology to boost capacity and safety. Several barriers hinder the widespread adoption of mechanized cassava processing. High machine costs make advanced technologies more accessible to large industries than to small-scale farmers, while local innovations in countries like Ethiopia remain constrained by low capacity and untested efficiency (Musa et al., 2020). Additional factors such as tuber size variability, moisture content, non-uniform peel thickness, and inadequate technical design data further limit machine performance.

Mechanization in cassava processing presents a paradox between efficiency and accessibility. While modern machines significantly improve processing rates and product quality, their high costs and unsuitability for small-scale operations prevent widespread adoption among smallholder farmers who dominate agriculture in Africa (Musa et al., 2020). This indicates that technological advancement alone is not enough; equipment must be affordable, context-specific, and adaptable to local farming realities to truly enhance food security and open up economic opportunities.Another persistent issue is the use of mild steel in machine construction, which contributes to food contamination and low durability. Since material choice directly affects food safety, product quality, and the economic lifespan of machines, future designs must prioritize durable, food-grade materials like stainless steel (Musa et al., 2020). Ensuring this shift may also require the enforcement of stricter regulatory standards for processing equipment in developing regions, protecting both consumers' health and farmers' financial investment.

Table 1: Performance Metrics of Cassava Primary Processing Machines

Machine Type	Metric	Max Value	Min Value	Speed Range (rpm)	Key Issues/Limitations
Grater	Capacity (kg/h)	500	60	650-1500	Low capacity for small-scale electric graters; food contamination from mild steel (Musa et al., 2020)
	Efficiency (%)	97	91.56		
	Loss (%)	8.44	2.5		
Peeler	Capacity (kg/h)	306	60	120-450	Low average peeling efficiency (70.45%); flesh losses (5.09%); modest output for electrical peelers (Musa et al., 2020)
	Efficiency (%)	95	70.45		
	Flesh Loss (%)	5.09	4.3		
Slicer	Speed Range (rpm)	-	-	300-500	Inefficient, labor-intensive reciprocating types; non-food-grade mild steel; damaged slices (13.89%) (Musa et al., 2020)

Data compiled from Musa et al. (2020).

Energy-Efficient Drying Solutions

Flash dryer systems mark a major innovation in cassava processing, significantly improving food safety and product quality during the drying of starch and flour. Historically, oversized industrial dryers posed profitability challenges for small-scale processors, but recent co-designed "resized" flash dryer models now cater to smaller capacities ranging from 50–500 kg per hour, compared to the 8–10 tons per hour of large-scale dryers (FAO, 2019). This shift directly addresses accessibility for small processors, ensuring that drying technologies are no longer limited to large industrial operations.These energy-efficient flash dryers provide both economic and environmental benefits. Compared to existing models, they reduce energy consumption by at least 30%, lower production costs by 10–15%, and boost production capacity by up to 50% (FAO, 2019). These improvements result in an 8–10% increase in overall profitability for processing units. The "Scaling Flash Drying Cassava" project exemplifies this impact, aiming to expand production capacity by 25–50% in multiple cassava factories. Projections indicated an annual increase in demand for 10,000 tons of cassava roots and an additional USD 400,000 in income for 660 farming households, alongside training and sustainability assessments for long-term impact (FAO, 2019).The broader significance of resized flash dryers lies in their ability to transform cassava value chains by making advanced technology suitable for smallholders. By aligning innovation with the needs of smaller actors, these dryers expand cassava markets, enhance profitability, and promote inclusive growth. Furthermore, the ripple effects extend beyond processing, stimulating raw cassava demand, raising farmer incomes, and strengthening food security (FAO, 2019). This demonstrates how context-specific innovations can deliver multiplier effects across the agricultural ecosystem, benefiting farmers, processors, and markets alike.

Value-Added Cassava Products

Cassava's high starch content and versatility make it an important raw material for a wide range of value-added products, transforming it from a subsistence staple into a crop with substantial economic potential. Processing cassava also serves to reduce cyanogenic glucosides, improving safety and extending shelf life (Bradbury & Holloway, 1988). One of the most prominent products is cassava flour, available in both fermented and unfermented forms. High-quality cassava flour (HQCF) is increasingly recognized as a gluten-free alternative and a substitute for wheat flour in bread and confectioneries, reducing reliance on wheat imports and broadening cassava's market appeal in Sub-Saharan Africa (International Institute of Tropical Agriculture [IITA], 2012). Fermented products like garri, fufu, and abacha also play a central role in West African diets, offering accessible and long-lasting food options (Olukosi et al., 2012).Another critical derivative is cassava starch, widely used in food industries as a stabilizer, binder, and thickener, and in non-food industries for adhesives, textiles, paper, and bioethanol production (Onwueme& Sinha, 1991). The growing global demand for bioethanol as a renewable energy source further expands cassava's industrial potential (Balat, 2011). Beyond starch, cassava can also be processed into pellets and chips for animal feed, glucose syrup and other sweeteners for the food industry, and innovative bioplastics from cassava starch for sustainable packaging (Reddy et al., 2013).Innovations in fermentation technologies are also producing nutritionally enhanced cassava-based foods with improved sensory quality and shelf stability (Olukosi et al., 2012). Collectively, these value-added products enhance the income potential of cassava farmers and processors, stimulate rural industries, and create employment opportunities. By diversifying cassava's applications across food, energy, and industrial sectors, the crop is repositioned as both a driver of food security and a catalyst for rural economic development.

Innovations in Rice and Cassava Storage

Strategies for Post-Harvest Loss Reduction

Post-harvest losses (PHL) remain a critical challenge in rice and cassava production, accounting for up to 30–40% of agricultural output in developing regions (Parfitt et al., 2010). In Nigeria, cassava alone records national losses of about 35%, while global statistics show that 13.2% of food was lost after harvest in 2021, with Sub-Saharan Africa topping the chart at 19.95% (Food and Agriculture Organization, 2021; Ndunguru et al., 2021). A closer look at the value chain reveals that cassava farmers experience the highest PHL during peeling, harvesting, and transportation, while rice farmers encounter the greatest losses during threshing and transport (Ndunguru et al., 2021). These losses are driven largely by pest infestations, diseases, and rodent attacks for farmers, while processors grapple with inadequate storage facilities and pest-related damage. The ripple effects of PHL extend beyond productivity, leading to income decline, food insecurity, malnutrition, and unemployment in affected communities. In response, farmers and processors have adopted a variety of technologies to reduce PHL, including the use of mechanical driers, metallic silos, root choppers, shellers, specialized storage structures, and tarpaulins (Ndunguru et al., 2021). Such innovations have demonstrated significant success—for instance, ATASP-1 beneficiaries in Nigeria achieved a 49.48% reduction in rice losses and a 32.14% reduction in cassava losses at the national level (Ndunguru et al., 2021). Despite these advances, widespread adoption remains constrained by the high cost of machines, expensive transportation and labor, and limited government support. Although farmers acknowledge the effectiveness of these technologies, affordability and accessibility issues highlight the urgent need for policies that subsidize equipment costs, expand rural infrastructure, and incentivize local innovations to ensure that smallholder farmers can fully benefit from modern storage solutions.

Table 2: Quantitative Reduction in Post-Harvest Losses for Rice and Cassava in Nigeria

Crop	Economic Loss Before Project (₦)	Economic Loss At Completion (₦)	Percentage Reduction	Highest PHL Stage (by zone)
Rice	2,570,158	1,298,506	49.48%	Threshing (Adani-Omor, Kebbi-Sokoto, Bida-Badeggi), Transport (Kano-Jigawa) (Ndunguru et al., 2021)
Cassava	1,315,842	892,898	32.14%	Peeling (Adani-Omor), Harvesting (Bida-Badeggi), Transport (Kano-Jigawa) (Ndunguru et al., 2021)

Data compiled from Ndunguru et al. (2021).

The significant economic loss reductions—49.48% for rice and 32.14% for cassava at the national level in Nigeria (Ndunguru et al., 2021)—demonstrate that investments in post-harvest loss (PHL) technologies yield substantial financial returns, directly increasing farmer income and improving livelihoods. This shifts the perception of PHL mitigation from a mere cost center to a profitable investment, creating a strong economic incentive for adoption that extends beyond food availability to tangible financial benefits. Policymakers, therefore, should frame PHL interventions as integral economic development strategies rather than solely food security measures. However, widespread adoption is constrained by high technology costs, limited government incentives, and elevated labor expenses (Ndunguru et al., 2021), underscoring that technological solutions alone are insufficient. Successful implementation requires a multi-faceted approach—supportive policies, financial mechanisms such as subsidies or credit access, and continuous farmer training—to overcome economic and human barriers. A collaborative framework involving government, private sector, and extension services is crucial for translating the technological potential of PHL solutions into sustainable, real-world impact.

Advanced Storage Solutions

Hermetic storage bags represent a major advancement in grain preservation, functioning by creating an oxygen-depleted and carbon dioxide-enriched environment through the natural respiration of stored grains and living organisms inside a sealed space (Boxall & Tyler, 1986). This modified atmosphere not only prevents external moisture migration but also serves as a strong barrier against insect infestation, rodents, and mold growth (Boxall & Tyler, 1986). By limiting biological activity and maintaining grain quality, hermetic storage systems address some of the key challenges associated with traditional storage practices that often lead to substantial post-harvest losses.Empirical studies in India highlight the wide-ranging benefits of hermetic storage for smallholder farmers. Ragasa et al. (2021) found that pest, fungal, and rodent damage—commonly causing up to 10% grain loss—was nearly eliminated, while aflatoxin contamination was reduced by almost 75%, enabling farmers to meet premium market standards. Farmers using hermetic bags were also 30% more likely to delay sales and received up to 11% higher prices for maize, in addition to increasing household consumption from own stocks by 26% (Ragasa et al., 2021). With a unit cost of INR 80, reusable for four seasons, hermetic bags recover their investment within one season, offering strong financial and non-financial benefits. Beyond economic gains, the reduced aflatoxin levels enhance food safety, directly improving the utilization dimension of food security and contributing to better health outcomes (Ragasa et al., 2021).

Table 3: Economic Benefits of Hermetic Storage for Smallholder Farmers

Benefit Category	Quantitative Impact	Financial Return/Cost Recovery
Loss Reduction	Nearly 100% elimination of pest, fungal, rodent damage (from 10% in traditional) (Ragasa et al., 2021)	Increased quantity available for sale/consumption
Aflatoxin Control	~75% reduction; 4% contamination vs. 37% in traditional bags (Ragasa et al., 2021)	Access to high-value markets with premium prices
Price Increase	Farmers 30% more likely to sell later; 25% longer storage duration; 11% higher maize prices (Ragasa et al., 2021)	Increased revenue (e.g., INR 92.75 additional net revenue per 50kg bag if sold) (Ragasa et al., 2021)
Consumption Shift	26% increase in consumption from own stocks; 7% decrease from market sources (Ragasa et al., 2021)	Reduced costs by avoiding market purchases during lean season (e.g., INR 90 additional net revenue per 50kg bag if consumed) (Ragasa et al., 2021)
Cost Recovery	Full unsubsidized cost (INR 80) recovered in one agricultural season (Ragasa et al., 2021)	High return on investment

Data compiled from Ragasa et al. (2021).

Hermetic storage not only minimizes physical losses but also empowers smallholder farmers by allowing them to store grains for longer periods, enabling sales during favorable market prices and reducing dependence on costly purchases in lean seasons (Ragasa et al., 2021). This elevates storage from preservation to a strategic tool for income optimization and market resilience. In contrast, cassava remains highly perishable, with post-harvest physiological deterioration (PPD) limiting its shelf-life to just 2–3 days without processing. Although traditional methods such as reburial in soil, soaking in water, or waxing are used, they provide only marginal extensions and are often labor-intensive (Otoo et al., 2018).

Conclusion

Rice and cassava remain vital to global food security and economic growth, yet both face persistent challenges from climate change and high post-harvest losses. Recent innovations in rice processing, including precision milling technologies, sustainable practices that reduce energy and water use, and the development of diverse value-added products, are strengthening value chains and opening new markets. Likewise, cassava is being transformed from a subsistence crop into a versatile industrial raw material through mechanization, energy-efficient drying methods, and expanded applications in flours, starch, bioethanol, and bioplastics. Improved storage solutions, particularly hermetic bags, have further reduced losses, improved food safety, and enhanced smallholder farmers' access to profitable markets. However, widespread adoption of these technologies continues to be hindered by high costs, weak policy support, and the need for context-specific designs.

Recommendation

Mechanization should be tailored to the unique needs of different regions, ensuring affordability and accessibility for both smallholder and commercial farmers. Locally adapted equipment, efficient energy solutions, and scalable technologies can improve efficiency in rice and cassava processing while minimizing drudgery and labor costs.

Governments and stakeholders need to create enabling policies that provide subsidies, tax incentives, and accessible financing models to encourage investment in modern processing and storage technologies. Strengthening public-private partnerships will also help scale up infrastructure and reduce barriers to adoption.

Training programs and knowledge-sharing platforms are essential for equipping farmers, processors, and extension workers with the skills needed to adopt and maintain new technologies. Building technical expertise at the grassroots level ensures sustainability and maximizes the impact of innovations.

A holistic approach that connects producers, processors, marketers, and consumers is critical for enhancing efficiency and profitability. Strengthening market linkages, improving logistics, and encouraging value addition can create a more resilient and competitive rice and cassava value chain.

Adopting environmentally sustainable practices, such as energy-efficient processing, water conservation, waste recycling, and climate-smart agriculture, is necessary for long-term resilience. These strategies will help reduce greenhouse gas emissions, protect ecosystems, and ensure food security under changing climate conditions.

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