

# Cassava Post-Harvest Management in Kenya: Opportunity for Gari Production: A Review

 Ngulinzira Daniel Lucia, Serem Charlotte and  Were Gertrude

Department of Family and Consumer Science, School of Agriculture and Biotechnology, University of Eldoret, P.O. Box 112-30100, Eldoret, Kenya

## Abstract

Cassava (*Manihot esculenta*) is a vital climate resilience crop in Sub-Saharan Africa, ranking as the fourth most crucial staple globally. In Kenya, it is a second root crop after Irish potatoes and provides a significant source of food and income, particularly for smallholder farmers who comprise about 80% of agricultural producers. However, its potential contribution to national food and nutrition security remains underexploited due to severe post-harvest losses, low nutritional value, and the presence of toxic cyanogenic glycosides. This review synthesises peer-reviewed literature, policy documents, and technical reports published between 2015 and 2025 to examine cassava postharvest handling and value addition options in Kenya. Evidence shows that poor infrastructures accelerate PPD 72 hours after harvest, resulting in significant losses up to 23%. Although processing into gari has proven effective in reducing cyanide through fermentation and roasting while extending shelf life, its adoption in Kenya remains limited. Key barriers include a lack of awareness of the product, inadequate small-scale processing infrastructure, a lack of standardised gari quality specifications, weak market awareness, and consumer preference for fresh cassava roots. The review identifies critical research gaps, notably the limited Kenyan studies on gari scalability, consumer acceptance, and market integration. While policy initiatives such as Kenya's Agricultural Sector Transformation and Growth Strategy (ASTGS 2019–2029) emphasize value addition to reduce postharvest losses, implementation remains limited. The review concludes that targeted investment in small-scale processing technologies, development of Kenyan gari quality standards, and market-oriented research are essential to enhance cassava value addition through product diversification and strengthen food and nutrition security in Kenya.

**Keywords:** Cassava, post-harvest management, Gari, value addition, Kenya

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Correspondence: [lucia.daniel67@gmail.com](mailto:lucia.daniel67@gmail.com)

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## Introduction

Globally, cassava (*Manihot esculenta*) is the fourth most significant staple food, after rice, wheat, and maize, sustaining the diets of over a billion people (Adebayo, 2023). The crop is prized for its abundant starch content, which provides a significant source of energy, particularly in regions where other staple foods may be scarce (Alabi and Safugha, 2022). In Sub-Saharan Africa, cassava serves as a key crop for enhancing food security, poverty reduction, and climate resilience due to its tolerance of poor soil, drought, pests, and diseases with minimal input (Emongor et al., 2023).

Cassava has emerged as a pivotal crop in Kenya, particularly in regions like Western Kenya and the coastal areas, where it plays a crucial role in food security and economic sustainability for many households and is the second most vital root crop after potato (Emongor et al., 2023). Opondo et al. (2020) reported that approximately (70%) of the Kenyan's landmass consists of arid and semi-arid land (ASALS) that is characterised by low rainfall and high temperatures, which support cassava growth. Coupled with the adverse effects of climate change and the country's arid climate, major crops such as maize and beans tend to perform poorly. In Kenya, cassava is primarily grown in the Western, Coastal, and Eastern regions. Nonetheless, its cultivation is spreading to additional areas such as the Rift Valley and the Central parts of the country. Despite

its agronomic advantages, the cassava sub-sector in Kenya has not realized its full potential, in terms of commercialisation and utilisation (Opondo et al., 2020).

Recently national estimation indicated the annual production approximated as 1 million metric tonnes, despite an estimated potential exceeding 2 million tonnes under improved agronomic and post-harvest systems (Opondo et al., 2020). The study conducted by Chesang et al, (2025) which covered two counties, namely Siaya and Migori in western Kenya shows that production cost of 0.5 hectares, estimated at approximately to be as KES 2,500 due to family labor contributions with no major agronomic challenges in cassava production while in other area is has been estimated at approximately KES 14,000 per acre with yields averaging 40 to 50 sacks (100 kg each) per acre. Also, it has been noted that fresh cassava roots have a very limited shelf life of less than 72 hours after harvest, and post-harvest losses exceeding 23% have been reported in the Coastal and Western regions of Kenya (Abong et al., 2016).

On utilized side, it can be consumption when roasted, boiled, fried, or processed into flour and blended with maize and sorghum to prepare porridge or *ugali* (Chesang et al., 2025). This underscores not only cassava's ubiquity as a staple food but also its potential value as an industrial crop, highlighting a need for

product diversification strategies. The utility of cassava extends beyond its role as a food source; it serves as a significant ingredient for various products, thereby presenting vast potential for diversification. Traditionally, cassava was perceived as a 'poor man's crop,' but its reputation is shifting as innovative processing methods lead to the successful development of diverse products (Opondo et al., 2020). These include flour, dried chips, and cassava crisps, which have gained increasing popularity, especially in coastal regions where there is a greater variety of cassava products compared to other areas like Migori and Busia (Abong et al., 2016). Enhancements in processing technology, especially for smallholder farmers who comprise about 80% of agricultural producers (Opondo et al., 2023), will include the modification of multipurpose processing machines for better efficiency, facilitate this diversification, making cassava a valuable commodity for both subsistence and market sales (Chesang et al., 2025). All these play an important role in addressing the Sustainable Development Goals (SDGs) particularly SDG 1 (No Poverty), SDG 2 (Zero Hunger) and SDG 13 (Climate Action).

In contrast, West African countries such as Nigeria and Ghana have successfully transformed cassava into a commercial commodity through diversified processing, particularly the production of gari (Samuel et al., 2022). Gari is a fermented and roasted cassava product that is lightweight, shelf-stable for several months, and adaptable to multiple consumption forms. Unlike sun-dried products, gari processing relies on fermentation and roasting, making it less dependent on open-air drying conditions and more suitable for hot, humid, or unpredictable climates. To address these challenges, Kenya should diversify cassava products by adopting good and affordable value addition practices, such as Gari from

Western African countries, which are doing well in cassava crops, especially in Nigeria and Ghana.

Gari is a popular West African food product made from cassava roots that have been peeled, grated, fermented, pressed to remove water, and then roasted into dry, crispy granules (Samuel et al., 2022). Its production is particularly effective at reducing cyanogenic glycosides to safe levels through its unique fermentation and roasting process. It is similar in appearance to coarse semolina or couscous. It can be eaten in several ways, soaked in cold water or milk with sugar and groundnuts as a snack, or cooked in hot water as pre-cooked product to form a dough-like meal called stiff porridge or eba in West Africa or ugali in East Africa, often eaten with soups and stews (Olanrewaju and Idowu, 2017). It provides a specific solution for Kenya's ASAL regions, where high temperatures accelerate spoilage and limit storage options. By converting fresh roots into a dry, pre-cooked product, gari processing mitigates rapid deterioration, reduces losses, and enables year-round availability. Furthermore, gari aligns well with Kenyan cassava varieties (sweet and bitter) and existing smallholder production systems, as it can be produced at household level, cooperative, or intermediate mechanized scales. Beyond domestic consumption, gari is a major trade commodity within West African diaspora markets across Europe and North America, presenting Kenya with a potential niche export opportunity.

The limited adoption of gari in Kenya reflects gaps in consumer awareness, processing infrastructure, quality standards, and empirical research on gari's scalability and acceptability in local contexts. Addressing these gaps is consistent with Kenya's Agricultural Sector Transformation and Growth Strategy (ASTGS, 2019–2029). Therefore, this review aims to give broad overview on

post-harvest challenges of cassava in Kenya and evaluate gari production as a potential value-addition strategy to reduce losses and enhance food security.

## Review Methodology

This study adopted a narrative review approach which gives a broad overview on cassava post-harvest management and the potential for gari production in Kenya, with emphasis on identifying patterns, trends, and knowledge gaps rather than summarizing individual studies. Literature was sourced from peer-reviewed journals, academic books, theses, government publications, and grey literature from organizations such as FAO, WHO, and KALRO. Searches were conducted in Google Scholar, ScienceDirect, SpringerLink, and ResearchGate, focusing on studies published between 2015 and 2025 to prioritize recent technological developments and current policy frameworks, including Kenya's Agricultural Sector Transformation and Growth Strategy (ASTGS). A structured search strategy using Boolean operators was applied, for example: "cassava" AND "post-harvest losses" AND "Kenya"; "cassava" AND ("value addition" OR "processing"); "cassava" AND "cyanogenic glycosides" AND "detoxification"; "gari production" AND "Africa". Searches were limited to English-language and, where possible, peer-reviewed sources. Approximately 1,200 records were initially identified. After removing duplicates and screening titles and abstracts, about 180 full texts were reviewed, with over 45 sources ultimately synthesized. Articles were included if they (1) addressed cassava production or post-harvest management in Africa, particularly Kenya; (2) discussed processing or detoxification methods relevant to gari; or (3) examined socio-economic, nutritional, or policy aspects of cassava value addition. The

review followed PRISMA-informed steps adapted for narrative synthesis: identification, screening, full-text assessment, and inclusion. A basic critical appraisal assessed clarity, methodological transparency, relevance, and source credibility, with grey literature evaluated for institutional reliability. Findings were coded manually and organized through qualitative thematic analysis into five themes: post-harvest losses, nutritional profile, cyanogenic glycosides and detoxification, processing practices, and opportunities for gari production. This approach enabled the identification of recurring patterns, gaps, and policy-relevant insights for Kenya's cassava value chain.

## Result and Discussion

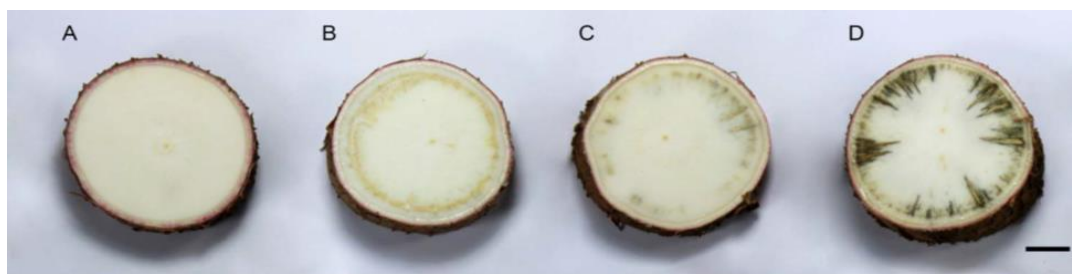
### Cassava Post-Harvest Loss

Post-Harvest Loss (PHL) is a critical bottleneck in the global food system, acting as a primary driver of food insecurity and poor livelihoods for smallholder farmers. In Kenya, cassava PHL remains high due to inadequate rural infrastructure and the rapid onset of Post-harvest Physiological Deterioration (PPD). Current estimates suggest that PPD accounts for over 23% of losses in freshly harvested roots within 72 hours of harvest (Abong et al., 2016). This perishability significantly diminishes the income potential of farmers who rely on the crop as a primary source of livelihood (Odoli et al., 2019).

Research identifies the harvesting stage of cassava roots as the most vulnerable point in the value chain. As noted by Chiekezie et al. (2023), losses at this stage stem from improper field handling, physical wounding of the tubers, and adverse environmental conditions. Because cassava roots lack a protective periderm (bark) capable of rapid wound healing, mechanical injuries during

harvest trigger an oxidative burst. This involves the accumulation of Reactive Oxygen Species (ROS), leading to vascular streaking and browning within 24 to 72 hours (Zainuddin et al., 2018; Mbinda & Mukami, 2022). High moisture content (70–80%) further accelerates this deterioration by increasing respiration rates and facilitating microbial spoilage (Nuwamanya et al., 2019). Nuwamanya et al. (2019) reported that several post-harvest mitigation strategies, including storage in moist sawdust or jute sacks, as well as pruning and waxing, have been recommended to significantly reduce post-harvest physiological deterioration (PPD) in cassava roots. These techniques create a controlled microenvironment

that moderates moisture loss and limits pathogen exposure, thereby extending tuber shelf life. However, despite their proven effectiveness, adoption among Kenyan smallholder farmers remains limited due to cost and logistical constraints, rendering immediate processing into gari a more feasible post-harvest management option. Additionally, Abong et al.'s (2016) study revealed that value addition via processing remains the most viable long-term strategy. Processing not only reduces the root's high moisture content and bulkiness but also halts the biochemical processes of PPD, transforming a highly perishable tuber into a safe and shelf-stable cassava commodity.



**Figure 1:** Cassava Postharvest Physiological Deterioration (PPD) after harvesting. *A: Root slice at harvest (zero days), B: Root slice at 2 days after harvest, C: Root slice at 4 days after harvest, and D: Root slice at 7 days after harvest. (Source: Adopted from Zainuddin et al, 2018)*

Figure 1 illustrates this progression: panel A shows a freshly harvested root with intact white parenchyma tissue; panel B (2 days) reveals the onset of faint vascular streaking; panel C (4 days) shows pronounced browning of vascular tissues; and panel D (7 days) exhibits extensive dark discoloration and parenchyma browning. These visual changes reflect primary PPD driven by oxidative stress and enzymatic reactions, which subsequently predispose the roots to secondary PPD through microbial invasion. Such deterioration rapidly diminishes starch quality, palatability, and market value, resulting in substantial income losses.

### Nigeria as a Case Study

Nigeria serves as a global benchmark for cassava production and utilization (Adebayo, 2023). While Kenya struggles with losses exceeding 23%, Bamikole et al. (2022) estimated that PHL in certain Nigerian regions is significantly lower, at approximately 13%. This reduction is largely attributed to a well-established value-addition culture. In states like Osun, inadequate storage facilities which otherwise would cause a 25% loss have driven 62.5% of smallholder farmers to immediately convert fresh harvests into gari (Jimoh et al., 2025). The economic viability of this transition is evident in the financial returns for

processors. Jimoh et al. (2025) reported a Benefit-Cost Ratio (BCR) of 1.73 for cassava production and processing, representing a 73% return on investment. This suggests that for every unit of currency invested for gari production, farmers realize a net profit of 0.73. This Nigerian model demonstrates that gari production is not merely a food security measure but a highly profitable commercial enterprise. Integrating similar processing hubs in Kenya could provide the necessary economic incentive for farmers to move away from subsistence farming toward market-oriented agro-industrialization.

### Nutrition Profile of Cassava

Cassava's roots are characterised by high moisture content of approximately 60-70% and 30-40% dry matter, which contains a high percentage of starch (Mwai et al., 2018). The nutritional value of cassava roots varies significantly depending on several factors, including genetic variety, growth conditions, and processing methods. Cassava roots are rich in calories, primarily from carbohydrates; their contribution to a balanced diet is insufficient on their own due to low protein and micronutrient contents (Alabi and Safugha, 2022).

While cassava is rich in carbohydrates, its nutritional profile is poor; it lacks essential proteins, vitamins, and minerals (Table 3.1). The nutritional challenges associated with consuming cassava roots, especially for populations that rely on it as a staple food, include its low protein content, lack of essential fatty acids, and deficiencies in micronutrients, which are critical for human health. Uchekukwu-Agua et al. (2015) highlighted the low 2% protein content of cassava, which poses health risks, especially for communities lacking access

to other alternative protein sources. Additionally, the protein in cassava roots is limited in the sulfur-containing amino acids methionine and cysteine, which are crucial for various bodily functions, including tissue repair and immune response (Bayata, 2019). According to Okwuonu et al. (2021), there is a strong correlation between over-reliance on cassava and the prevalence of protein-energy malnutrition, vitamin A deficiencies, and nutritional anaemia. The findings by Nicodemas et al. (2019) indicated that the contribution of cassava to the Recommended Dietary Allowances (RDAs) of the respective nutrients was 19.4% for iron, 21% for zinc, 0.527% for fat, and 4.26% for protein among the under-five children, which is extremely low.

Various efforts have been made to address this problem, including supplementation, fortification, and food-based diversification, which are being employed to tackle micronutrient deficiencies. However, to achieve broader impact and sustainability, biofortification of staple foods such as cassava is also being explored, and genetic engineering and traditional breeding techniques have been employed to develop varieties of cassava with enhanced levels of provitamin A carotenoids together with food-to-food fortification by using locally available food (Okwuonu et al., 2021; Farinde et al., 2023). Furthermore, utilizing cassava in composite product formulations has emerged as an innovative strategy to improve its nutritional profile, particularly in addressing the significant protein deficiencies associated with a cassava diet. Research by Dada et al. (2017) demonstrated that combining cassava flour with other protein-rich foods, such as cowpea and soy, enhanced the overall nutritional quality of the products.

**Table 1:** Comparative nutrient composition of selected staple foods in Kenya (per 100 g, fresh basis)

Nutrients	Cassava	Maize	Rice	Wheat	Irish potato	Sweet potato	Plantain
Energy (kcal)	173	345	345	328	105	101	97
Water (g)	53.8	13.6	12.0	12.5	72.1	72.0	73.6
Protein (g)	1.3	7.9	7.0	11.3	2.4	1.7	1.4
Fat (g)	0.3	4.5	0.5	2.5	0.1	0.4	0.4
Carbohydrate (g)	39.1	63.4	76.2	58.0	22.7	20.8	20.1
Fibre (g)	4.6	9.4	3.7	14.0	1.7	4.0	3.6
Ash (g)	1.0	1.2	0.6	1.7	1.0	1.2	0.9
Calcium (mg)	33	9	9	39	9	22	7
Iron (mg)	0.9	2.6	1.7	4.0	1.4	0.4	0.8
Magnesium (mg)	13	110	26	125	19	12	23
Phosphorus (mg)	21	323	125	315	81	25	29
Potassium (mg)	250	258	100	366	645	389	322
Sodium (mg)	2	12	6	3	6.5	20	10
Zinc (mg)	0.3	1.9	1.1	3.0	0.3	0.3	0.2
Selenium ( $\mu\text{g}$ )	1	9	1	48	1	0	1
Vitamin A ( $\mu\text{g}$ )	1	0	0	1	0	17	1
Vitamin C (mg)	38	0	0	0	6.6	18	23.3

*Note. Values are per 100 g edible portion (fresh basis). Data compiled from Mwai et al. (2018).*

Table 1 compares the nutrient content of cassava root with other common staple foods in Kenya using the Kenya Food Composition Table (2018), including maize, rice, wheat, Irish potato, sweet potato, and plantain, based on the Kenyan food composition table. The data shows that cassava root provides a moderate level of energy (173 kcal/100 g), largely derived from carbohydrates (39.1 g/100 g), but it is relatively poor in protein (1.3 g/100 g) and fat (0.3 g/100 g). Compared to cereals such as maize (7.9 g protein) and wheat (11.3 g protein), cassava is clearly a low-protein, high-energy food source. This nutritional profile underlines cassava's importance as an energy security crop but also its limitation as a sole dietary staple.

The high moisture content of cassava (53.8 g/100 g) contributes significantly to its rapid post-harvest deterioration. Unlike cereals and grains

that can be stored for extended periods, cassava roots begin to spoil within 24 hours of harvest due to physiological and microbial deterioration. This perishability is a major cause of post-harvest losses in Kenya and other cassava-growing regions. Although when you compare with other root and tuber crops, cassava contains a moderate amount of moisture, its rapid post-harvest deterioration is not primarily due to water content but rather to unique physiological and biochemical factors. Unlike other roots such as sweet potato and Irish potato, which often have even higher moisture levels yet store longer compared to it, cassava undergoes post-harvest physiological deterioration (PPD) within 24–72 hours after harvest. Mbinda & Mukami (2022) described PPD as a complex process that is linked to enzymatic stress responses to wounding, involving changes in gene expression, protein synthesis, as well as accumulation

of secondary metabolites and can be influenced by environmental factors.

Visually, PPD is characterised by a blue/black or brown discolouration of the vascular parenchyma. This is caused by oxidation of phenolic compounds, high respiration rate, and lack of a protective periderm to heal wounds, which together accelerate enzymatic browning and microbial decay (Mbinda and Mukami, 2022). Other root crops possess thicker skins and stronger wound-healing capabilities that slow spoilage after harvesting (Abewoy, 2021). Cassava root experiences unusually rapid PPD especially when wounded. This is probably due to cassava roots not being propagules and, as a result, not serving any biological function once detached from the plant. Dankwa et al. (2025) pin point this by reporting that cassava roots are not propagules, hence lack the biological mechanism to self-preserve once detached from the plant. However, live cassava plants are able to repair wounded roots when remain attached to the main plant. While wounded storage roots remaining attached to the plant are capable of wound repair (Zainudin et al., 2018). Consequently, cassava's extreme perishability highlights the importance of immediate post-harvest processing, such as conversion into gari, to prevent losses, extend shelf life, and add value within Kenya's cassava value chain by doing product diversification.

The conversion of fresh roots into gari not only extends shelf life by several months but also enhances marketability and reduces transport bulk and promote nutrients addition. During gari production, grating, dewatering, fermentation, and roasting steps give room for removing cyanogenic compounds simultaneously with the addition of some nutrients, thereby improving safety and storage stability. According to the study conducted by Akpogheli et al. (2025) reported that stage like fermentation

during Gari production not only extends shelf life by creating an acidic environment that limits spoilage, but also reduces antinutritional factors like phytates and cyanogenic glycoside through microbial activity which enhances bioavailability of essential minerals such as iron and zinc by releasing them from mineral-phytate complexes and making them more accessible for absorption after consumption. Moreover, gari can be easily fortified with protein- and micronutrient-rich ingredients, staple foods (such as soybean flour or palm oil) to address cassava's inherent nutritional deficiencies. Also, because Gari is used as an instant product to make Ugali, its utilisation will always be accompanied by sauce, such as meat, fish, egg, and beans, which will boost the accessibility of other nutrient content (Akpogheli et al., 2025).

### **Cassava Cyanogenic Glycoside**

Cassava roots and leaves naturally contain cyanogenic glycosides, primarily linamarin and lotaustralin, which, upon enzymatic hydrolysis release toxic hydrogen cyanide (HCN), posing serious health risks if not processed well. Morgan and Choct (2016) demonstrated that these glycosides undergo hydrolysis under specific physiological conditions, emphasising the critical role of proper processing in reducing cassava toxicity. Reports by Kashala-Abotnes et al. (2019) indicate that prolonged consumption of improperly processed cassava is associated with severe neurological disorders, notably konzo, a disease characterised by the sudden onset of irreversible paralysis of the lower limbs. Cyanogenic glycosides are also implicated in Tropical Ataxic Neuropathy (TAN), a chronic neurological condition marked by vision loss, hearing impairment, and progressive weakness of the limbs (Domínguez & Landa, 2020; Chen and Wu, 2024). Consequently, several deaths attributed to cyanide poisoning from

cassava consumption have been reported in various regions, including Western Kenya (Ojiambo, 2019). The cyanogenic glycoside content of cassava varies widely depending on cultivar, environmental conditions, and post-harvest handling. Bayata (2019) reported cyanide equivalents ranging from 53 to 1,300 mg/kg dry weight in cassava leaves and from 10 to 500 mg/kg dry matter in root parenchyma values that exceed recommended safety limits. Bitter cassava varieties, in particular, often surpass the FAO/WHO guideline of <10 mg/kg dry matter set to prevent acute toxicity (Alhassan, 2017). Ndubuisi and Chidiebere (2018) classified cassava cultivars as “bitter” or “sweet” based on their cyanogenic glycoside content: bitter varieties may contain 15–400 mg HCN equivalents per kilogram of fresh roots, whereas sweet varieties typically contain 15–50 mg/kg. All of it must be processed into WHO recommended standard.

Processing methods that effectively target cyanogenic glycosides are therefore essential. Gari production is particularly effective because it combines fermentation and roasting, two complementary detoxification mechanisms. Akpoghelie et al. (2025) reported that during fermentation, endogenous and microbial enzymes hydrolyse linamarin and lotaustralin into cyanohydrins, thereby destabilising the glycosides. Subsequent roasting applies heat that decomposes these cyanohydrins and drives off the resulting volatile HCN gas. This sequential breakdown and volatilisation process markedly reduces residual cyanogenic compounds, making

gari substantially safer than minimally processed cassava products. Thus, gari production not only extends shelf life but also provides a robust biochemical barrier against cyanogenic toxicity in cassava-based diets.

### Approaches Used to Remove Cyanogenic Glycosides from Cassava

Cyanide content in cassava (*Manihot esculenta*) poses significant health risks, primarily due to the presence of cyanogenic glycosides, which can release toxic cyanide upon hydrolysis. Ndubuisi & Chidiebere (2018) have reported that cassava varieties are often categorised as either sweet or bitter, signifying the absence or presence of toxic levels of cyanogenic glucosides, respectively. The so-called sweet (actually not bitter) cultivars can produce as little as 20 milligrams of Cyanide (CN) per kilogram of fresh roots, whereas bitter ones may produce more than 50 times as much (1 g/kg). The safe consumption of cassava is mainly dependent on effective detoxification methods. Recent studies, including Peprah et al. (2020), have emphasised the need for education and training on proper processing methods to ensure that communities are aware of the risks and best practices for preparing cassava safely. Five methods stand out for their efficacy in reducing cyanide levels in cassava: fermentation, soaking, drying, boiling, selective breeding, and biofortification. Each technique has its mechanisms of action, benefits, and limitations, which are essential for understanding its potential applications in improving the safety of cassava products.

**Table 3.** Comparative summary of cyanide reduction methods in cassava processing

Method	Effectiveness	Advantages	Limitations	References
Fermentation	Achieves significant hydrogen cyanide (HCN)	Improves flavor, shelf life, and safety; enhances	Requires controlled conditions; fermentation	Ogbonnaya (2016); Kolapo et al. (2021):

	reduction, 85%–90%.	nutrient bioavailability.	time and microbial strains influence outcomes.	Kuliah Sari et al., (2021),
Soaking	Reduces cyanide by 80–90% after 24–48 hours; soaking in running water is most effective.	Simple, low-cost, and suitable for rural settings; improves palatability.	Requires access to clean water; prolonged soaking may cause microbial contamination.	Indrastuti et al. (2019); Hawashi et al. (2019)
Drying	Can reduce cyanide 60%–80%; sun drying is generally more effective than oven drying.	Inexpensive, scalable, and suitable for rural climates; preserves cassava.	Dependent on weather conditions; inconsistent drying may cause uneven detoxification.	Ndubuisi & Chidiebere (2018); Okeke et al. (2023); Atlaw (2018); Morgan & Oloya (2017)
Selective breeding and biofortification	Genetic improvement offers sustainable detoxification when combined with other methods.	Provides a long-term and sustainable solution; enhances nutritional value (vitamin A, Fe, Zn).	Time-intensive; may require regulatory approval; potential concerns regarding genetic diversity.	Ogbonna et al. (2020); Chaicharoen et al. (2023); Gomez et al. (2023); Inácio et al. (2024)
Boiling	Removes 87–99% of cyanide depending on boiling duration and particle size; extended boiling increases detoxification efficiency.	Simple, practical, and widely accepted processing method.	Some studies report 99% reduction usually requires small pieces and large volumes of water, which is often not practiced, making it a risky method compared to fermentation	Ojiambo et al. (2017); Ubwa et al. (2015); Kashala-Abotnes et al. (2018); Ngungulu et al. (2024)

**Note.** Data compiled from multiple sources as cited in the table.

### Combination of Processing Methods

To increase the efficiency of cyanogen removal, efficient processing techniques are usually combined with others that are less efficient, and most of these methods are implemented together, such as soaking and fermentation, fermentation and drying, or

selective breeding/bio fortification and boiling for better results. A study conducted by Onyango et al. (2021) supported this idea that a combination of fermentation and other traditional processing methods effectively lowers cyanogenic compounds to the recommended standard. Moreover, the

fermentation not only detoxifies cyanide but also enhances the nutritional profile of processed cassava products (Terefe et al., 2022). Drying of cassava roots reduces the cyanide content by about 50% while peeling, washing, drying, and fermentation reduce cyanide content by about 70 % (Onyango et al., 2021). Ismaila et al. (2018) conducted a related study and reported that fermentation reduces cyanide contents by more than 60%. So, Onyango et al. (2021) and Ismaila et al. (2018) both studies came up with an agreement that in order to get an efficient result of reducing cyanide, a combination of processing procedures should be employed without ignoring fermentation. This aligns with findings from GANA (2023), which reported that a combination of fermentation/roasting, or fermentation/boiling, or boiling/ roasting, and fermentation/roasting should be employed to reduce the cyanide content of cassava. Also, Terefe et al. (2022) noted that the fermentation method of at least 3days can reduce cassava cyanide up to 97.17%, which is an excellent outcome. Collectively, these results support the traditional gari production process, which incorporates both fermentation and roasting stages to ensure substantial cyanide reduction.

### **Current Practices in Cyanogenic Glycoside Management in Kenya**

In Kenya, a combination of traditional and modern methods are employed to reduce cyanide levels in cassava, ensuring its safety for consumption. Traditional techniques such as fermentation, soaking, drying, and boiling are widely practiced across cassava-growing regions, including Western, Nyanza, and the Coastal areas, where they form part of indigenous food preparation knowledge (Ndubuisi & Chidiebere, 2018). Fermentation and soaking remain particularly popular due to their simplicity, low cost, and

effectiveness in reducing cyanogenic glycosides, especially in smallholder and household processing contexts (Kolapo et al., 2021; Hawashi et al., 2019). Sun-drying is commonly used for preparing cassava flour and chips, allowing for significant volatilization of hydrogen cyanide under Kenya's tropical climate (Okeke et al., 2023). Boiling, though often practiced at the household level, serves as a rapid detoxification method, especially when combined with cutting cassava into smaller pieces or pre-soaking (Nyirenda, 2021; Ojiambo et al., 2017). In addition to these traditional methods, Kenya has embraced selective breeding and biofortification through national and international research collaborations, such as those led by the Kenya Agricultural and Livestock Research Organization (KALRO) and the International Institute of Tropical Agriculture (IITA). These initiatives have introduced low-cyanide and provitamin A-enriched cassava varieties to enhance both food safety and nutritional quality (Ogbonna et al., 2020; Lawal et al., 2021). Despite progress, challenges remain in scaling up these improved varieties due to limited farmer awareness and distribution networks. Nonetheless, the integration of traditional processing techniques with modern breeding strategies represents a holistic approach to cassava cyanide management in Kenya.

### **Cassava Processing in Kenya**

Cassava is an underutilised crop that is gaining prominence in the wake of climate change; different parties are interested in farmers diversifying into its production and commercialisation (Opondo et al., 2023). Cassava is not only used as a staple food but also as a cash crop, which demands proper value addition (Bokundabi et al., 2023). Processing is the best method, which involves different procedures and helps to address the challenges facing the cassava

crop, like post-harvest loss, poor nutrition profile and cyanogenic glycoside. One of the primary reasons cassava requires processing is its content of cyanogenic glucosides, which can lead to toxicity if not adequately handled, particularly in bitter varieties of cassava that yield higher levels of these compounds (Bokundabi et al., 2023).

Economically, Cassava processing creates a variety of products that fulfil both local and international market demands, adding significant value to the crop. Processing transforms fresh cassava roots into products such as flour, starch, and chips, which have extended shelf lives and are easier to market (Uchechukwu-Agua et al., 2015). The socio-economic benefits derived from processing training, which leads to improved livelihoods for women engaged in cassava farming. Abong et al. (2016) observed that cassava processing in Kenya is largely undertaken by women, a trend rooted in longstanding perceptions of cassava as a crop associated with poverty and marginalized communities. This perception suggests that the cassava value chain remains underdeveloped and undervalued, despite the crop's considerable potential to enhance food security and climate resilience. Additionally, the authors identified several constraints limiting cassava processing in Kenya, including irregular and insufficient raw material supply, low and seasonal demand for cassava products, the high perishability of fresh cassava roots, limited value addition, inadequate access to appropriate processing technologies, and weak organizational structures among value chain actors.

Collectively, these challenges continue to constrain the crop's competitiveness and market image. Moreover, Abong et al. (2016) findings indicated that value addition to cassava remains minimal within the study regions, emphasizing the need for the

development and dissemination of innovative processing technologies, alongside the diversification of domestic and industrial cassava-based products. Finally, suggested that enhancing consumer awareness and education regarding cassava processing and utilisation is deemed critical for promoting the crop's acceptance, utilisation, and broader adoption.

### Opportunities for Gari Production in Kenya

The raw material for gari production is cassava roots, which are processed either through traditional or modern methods. The traditional method involves harvesting, peeling, wet cleaning (washing), grating, fermentation, dewatering, sieving, and roasting to gelatinise the starch before cooling. The modern method employs mechanised equipment such as motorised graters, hydraulic or screw presses for dewatering, mechanical sieves, and rotary or drum roasters to improve efficiency, hygiene, and scale (Akpogheli et al., 2025). Gari is a pre-gelatinised (pre-cooked), ready-to-use product commonly consumed by soaking in cold water with sugar and roasted groundnuts or by reconstituting it in hot water to form a stiff dough known as *eba* or *ugali*. Unlike Kenyan *ugali*, which is typically maize-based and neutral in taste, *eba* has a distinctive fermented, tangy flavour profile. This sensory difference is important for Kenyan consumers, as it represents both a culinary novelty and a potential barrier that must be addressed through awareness and adaptation.

Also, Akipogheli et al. (2025) reported that due to its performance in household consumption and markets, gari has expanded beyond West Africa to other African countries such as Mozambique, where it is locally known as *rale* and consumed as a snack. Given the existing challenges in cassava processing, marketing, and utilization in Kenya, these

conditions create a favorable environment and strong justification for promoting gari production as an innovative post-harvest and value-addition strategy. Cassava roots are highly perishable and begin to deteriorate within 24 to 72 hours after harvest (Zainuddin et al., 2018), contributing to post-harvest losses of up to 23% in Kenya's cassava value chain (Abong et al., 2016). Gari processing transforms fresh cassava into a dry, shelf-stable product that can be stored for months without spoilage (Oluwatusin, 2017). By introducing gari production at the community or cooperative level, farmers can process their cassava immediately after harvest, minimizing post-harvest losses and ensuring continuous income and availability of cassava throughout the year.

Gari processing provides an avenue for establishing intermediate-scale, mechanised processing units that are affordable and adaptable to rural settings, even at the household level, such as motorised graters, hydraulic or screw presses for dewatering, mechanical sieves, and rotary or drum roasters. These facilities can be developed through cooperative or public-private partnership models, enhancing local processing capacity and generating employment. Currently, cassava utilisation in Kenya is dominated by traditional forms such as boiled or roasted roots, with minimal transformation into high-value products (Emongor et al., 2023), reflecting limited value addition along the cassava value chain (Opondo et al., 2023). Gari offers a new value-added product line that is convenient, affordable, and versatile. Its long shelf life and ease of preparation, requiring less cooking time and fuel than maize ugali, make it particularly attractive in urban Kenya, where charcoal and gas costs are high. This energy-saving attribute represents a significant market advantage. Gari production can elevate cassava from a subsistence crop to a

commercial commodity, stimulating industrial growth and rural entrepreneurship.

Cassava markets in Kenya are fragmented and often exploit farmers through middlemen, with price fluctuations discouraging consistent production and investment (Omondi et al., 2024). Gari's storability and transportability allow producers to sell when prices are favourable and access wider markets. Beyond domestic trade, gari is a major commodity within West African diaspora markets across Europe, North America, and other regions, offering Kenya a potential niche export opportunity. By stabilizing market access and product quality, gari can improve income predictability for both farmers and processors.

Kenya's cassava product range remains narrow, with limited innovation and consumer awareness of processed options (Opondo et al., 2023). Introducing gari increases product diversity and familiarises consumers with a convenient, ready-to-eat cassava product. With appropriate marketing and adaptation, gari can appeal to urban consumers seeking quick, nutritious foods and serve institutional markets such as schools, hospitals, and relief programs. Amwata (2020) and MoALFC (2019) reported that Kenya's Agricultural Sector Transformation and Growth Strategy (ASTGS, 2019–2029) emphasises value addition, agro-industrialisation, and food security. Several county governments (Busia, Kisumu, Kilifi, and Migori) have also prioritised cassava as a key crop for livelihood improvement under current situation of climate change. This policy framework provides an enabling environment for investment in gari processing enterprises, particularly for youth and women, and opens opportunities for partnerships, grants, and capacity-building initiatives in agribusiness development.

## Conclusion

This review has demonstrated that cassava plays a central role in enhancing food security across many African countries, including Kenya, owing to its resilience and adaptability to diverse agroecological conditions. Despite these advantages, the crop's full potential in Kenya remains constrained by substantial post-harvest losses, low nutritional value in traditional products, and the presence of toxic cyanogenic glycosides. Although several processing methods exist to mitigate these challenges, most are limited in scale and effectiveness, resulting in minimal value addition and weak market competitiveness.

## Recommendation

To successfully establish a gari-processing industry in Kenya, the following multi-stakeholder actions are recommended:

1. The Ministry of Agriculture and county governments should incentivise the acquisition of appropriate mechanised equipment, particularly motorised graters and hydraulic presses, or farmer groups and cooperatives, enabling a transition from labour-intensive traditional methods to efficient, scalable processing systems.
2. The Kenya Bureau of Standards (KEBS) should develop and enforce national quality and safety standards for gari, with emphasis on moisture content (<12%) and residual cyanide levels (<10 mg/kg), in order to build consumer confidence and facilitate entry into formal retail and institutional markets.
3. Research institutions and extension services should promote food-to-food fortification by encouraging the

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blending of cassava with locally available, protein-rich legumes such as soybean or cowpea during processing. This innovation would enhance the nutritional profile of gari and contribute to addressing protein-energy malnutrition.

4. Targeted marketing and consumer-awareness campaigns are necessary to reposition cassava-based products as modern and convenient foods, highlighting gari's pre-gelatinised, instant-preparation attributes to urban consumers and institutional buyers.
5. Training programs in post-harvest handling, processing, entrepreneurship, and financial literacy should prioritise women and youth who constitute the majority of the cassava labour force, ensuring that they lead and benefit from the transition toward commercial gari production and value-added agribusiness. Together, these interventions provide a coherent framework for mainstreaming gari production in Kenya and for unlocking the untapped economic and nutritional potential of cassava.

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