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Roots, Tubers
and Bananas

A guide to the production of High-Quality Cassava Peel® mash as a feed for livestock



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A guide to the production of High-Quality Cassava Peel® mash as a feed for livestock

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Summary

Cassava is a staple root crop grown in the humid tropical regions of the world. The raw tubers are mostly processed in small processing units using manual labour. The process is known as 'garri processing' and involves hand peeling, grating and pressing to extract starch as a human foodstuff. Garri processing generates considerable quantities of cassava peel which form a waste product that is an environmental hazard. Cassava peel can be converted from a waste product into a high-quality, valuable and economically attractive livestock feed ingredient with similar albeit slightly lower nutritional value compared to the more widely used maize meal. The resultant mash is particularly suitable as an energy source for poultry but is also suitable as a starch source in pig, fish and ruminant feeding systems. In 2015, CGIAR scientists demonstrated the technical and economic feasibility of transforming cassava peels into a high-quality animal feed. The resulting product is now registered through the Trademarks, Patents and Designs Registry, Commercial Law Department of the Federal Ministry of Industry, Trade and Investment in Nigeria as a feed ingredient: 'High Quality Cassava Peel® mash' (HQCP®).

This training manual provides guidelines to prospective processors. Our aim is to provide standard processing methods to produce a uniform product with a quality and quantity that will meet the market requirements. This manual outline standard protocols for turning wet cassava peel into a stable feed ingredient, starting from sourcing of fresh wet peel and sorting (removal of unwanted materials). The manual describes further processes: grating of wet peels to reduce the particle size and facilitate dewatering using a hydraulic press. The final stages, pulverizing, sieving, drying and bagging, are outlined in detail. The manual provides good handling practices, business tips and relevant information on investment opportunities based on current information.

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I Introduction

Africa currently produces more than 150 million tonnes of fresh cassava tubers annually (FAOSTAT 2014). More than 95% of its production involves hand peeling of tubers which in turn generates up to 40 million tonnes of peels annually that is mostly waste. Cassava processing leads to production of 'garri', a human foodstuff (Box 1). In Nigeria, waste cassava peels tend to end up on dumping sites in southwest Nigeria, leading to considerable environmental pollution through generation of effluent. There is thus an opportunity to close the nutrient gap through conversion of waste peel into usable livestock feed. This will help to mitigate environmental damage as well as generating a valuable livestock feed, particularly for monogastric livestock and fish.

Cassava peel has been used for decades to feed livestock, particularly ruminants and pigs (Adesehinwa et al. 2016; Ngiki et al. 2014; Oladunjoye et al. 2010). Wet peels contain high moisture content and quickly deteriorate. In addition, fresh cassava contains hydrocyanic acid which generates free cyanide during processing with potential risks to human health. Since free cyanide is volatile, its concentrations can be considerably reduced or even eliminated during processing (Oke 1978). The major technical challenge limiting the use of cassava peels as an animal feed ingredient is the process of drying. Traditionally, cassava peels are sun dried on the ground. Proper sun drying is achieved in 1–3 days in the dry season but can take up to eight days during the rainy season. Although cost effective, traditional sun drying is slow and often encourages the growth of mould and other microorganisms including *Aspergillus flavus* (which is pathogenic), *A. fumigatus*, *A. cherahen*, *A. teirenus*, *A. flaripes*, *A. japonicus*, *A. niger*, *A. ochracuss*, and *Penicillium rubrum* (Clerk and Caurie 1968). This microbial growth exposes livestock to aflatoxicosis and/or myotoxic infection following feeding. Because of the high microbial load and potential presence of mycotoxins in sun-dried cassava products, the livestock feed industry and other direct users are cautious about its use based on concerns about product safety and hygiene. There is therefore a need for quicker drying methods which will reduce or eliminate microbial proliferation and ensure maximal cyanide detoxification (Okafor and Ejiofor 1986).

Box 1: Simple processing for garri production

- Peel the skin off the cassava tubers
- Wash the peeled tubers
- Grate/grind the tuber
- Pack the grated wet cassava paste into woven bags and dewater on hydraulic press for 2–3 day
- Sieve the fine moist cassava powder
- Toast the fine powder to dry
- Allow the toast grit to cool
- Sieve the toasted and dried and cassava grit (garri) to obtain a finer and uniform particle size (optional)
- Pack in bags for storage or consumption

CGIAR scientists at the International Livestock Research Institute (ILRI) have developed, beyond proof of concept, a technology which quickly reduces cassava peel moisture content to 10–12% within six sunshine hours using only equipment in current use by small-scale processors and households (Okike et al., 2015). Such equipment consists of mechanized graters and a hydraulic press. The considerably shorter processing time to dry the peels ensures high quality products, low in aflatoxin contamination, thus, allaying safety fears among potential users. There is now

evidence, through collaborative work with feed millers and livestock producers in Nigeria, of willingness to purchase large quantities of cassava peel products as a livestock feed ingredient.

These research efforts have led to a registered product, HQCP®. Laboratory analysis of HQCP® mash indicates that it is high in energy with an energy value of around nine millijoules (mj) per kilogram (kg) of dry matter (DM) which is roughly equivalent to two-thirds of the energy value of maize grain. A further indication of the quality of the product is the frequency of requests from feed manufacturers who order a constant supply of large volumes, which indicates a switch from use of maize meal, at least in part, to HQCP® mash in their livestock feed formulations.

There is an obvious need to increase capacity among processors to produce sufficient volumes of HQCP® mash. To achieve this goal, technical training of potential entrants to the market is needed to ensure standardized, quality product as required by HQCP® mash buyers. This manual sets out a raining plan targeted at HQCP® mash enterprises. The overall objective of the manual is to provide systematic guidelines for production of HQCP® mash with a view to supporting their move to commercial production.

Figure 1 Advantage of HQCP® mash production technology over the traditional method of drying.

Advantages of HQCP® mash production technology over the traditional method of drying

- drying time reduced three-fold
- safe and hygienic product
- compact product for more efficient transportation



Unprocessed sun-dried cassava peel



HQCP® mash

2 Production of HQCP® mash

This section describes a step-by-step process to guide the conversion of raw cassava peel into the finished product. The processing method and the significance of each processing step in terms of the impact on the quality of finished product are discussed in this section.

2.1 Step-by-step production process

Production of HQCP® mash involves sorting, grating, pressing, pulverizing, sieving, drying (which could be sun, toasting or flash drying), bagging and storage.

Raw Materials: Sourcing wet cassava peel

Wet cassava peel is a product from cassava processing lines. Wet peel can usually be sourced from a nearby cassava processing facility in sufficient daily quantities to run a small cassava peel factory to its determined capacity. The ratio of wet peel to dried fine mash is three to one. Sourcing from a distance will of course lead to higher total production costs. We recommend the use of fresh peels (less than 24-hours old) free from contaminants since the quality of the finished product is determined by the quality of the raw material used. When wet cassava peels are left for more than 24 hours, they undergo fermentation and become soggy and slippery and are difficult to grate.

Sorting

Stalks, large woody tubers and other foreign materials must be sorted out and discarded before grating the peels as they can damage the drum and rasper of the grater. Sorting is therefore an essential step towards prolonging the lifespan of the grater. Sorting is usually done by hand (Figure 2).

Figure 2: Sorting of wet cassava peels (Photo: ILRI/Tunde Amole)



Grating

The grater is similar to a regular grater used for grating fresh cassava tubers in the conventional production of garri except that two wooden blocks are used to keep the gap between the hopper and the drum narrow to ensure that fine peels do not escape passage through the grater (Figure 3). The grater uses a steel drum with corrugations/roughened sharp surfaces tightly arranged in a crisscross pattern across the surface of the drum (the rasper) to maximize grating.

Figure 3: Rasper with wooden block (Photo: ILRI/Tunde Amole)



The grater has a hopper through which the sorted wet peels move to the rasper by gravity, sometimes further facilitated by manually pushing the peels with a piece of wood to increase contact with the rasper (Figure 4). When dealing with fresh peels, the material must be grated three times as, given the relatively hard nature of the peels and their small size compared with whole tubers, the process of grating peels is not as efficient as when grating tubers where only one cycle of grating tubers is needed to achieve the desired particle size. On average, it takes about one hour for a 7.5 horsepower (hp) grater to grate 500 kg of fresh peels three times (Okike et al. 2015).

Figure 4: Grating of wet cassava peels (Photo: ILRI/Tunde Amole)



Physical dewatering (hydraulic pressing)

Physical dewatering is achieved by pressing of the grated material packed in woven plastic bags between wooden planks aided by a hydraulic press. Grated peels are packed in quantities of about 20 kg per bag (uniform bag size facilitates equal distribution of pressure). A sturdy board is placed at the bottom of the hydraulic press. Packed bags are arranged in layers (one over the other) in the sturdy metal cage of the hydraulic press (6) with the board beneath the pile. Once the press is full, a further board is placed on top (Okike et al. 2015). The moisture content of the dewatered mash (post pressing) does not vary by season because dewatering relies on pressure and not on atmospheric humidity. After pressing, the first intermediate product, HQCP® cake, is achieved and this product has a moisture content of about 30–40%. This intermediate product can be fed to ruminants and pigs although it has a short shelf-life of around seven days. It can be transported more efficiently than wet cassava peel because dewatering results in removal of approximately 50% of the water from raw peel.

Figure 5: Dewatering of grated cassava peels (Photo: ILRI/Tunde Amole)



The pressed material (HQCP® cake) should be left overnight before proceeding to drying. This ensures an initial fermentation, necessary for a quality product, and also leads to further elimination of hydrogen cyanide (HCN).

Pulverizing

Dewatered material off the press is in the form of lumps that need to be loosened to improve flow through a sieve. This is achieved by passing the cassava peel lumps through a pulverizer. A small hammer mill can be used for this pulverization step; however, a further pass through the grater will suffice.

Sieving

The loosened material is sieved (Figure 6) to separate the coarse fraction that is high in fibre which limits the use of peels in monogastric rations. Sieving is aided by a motor-driven shaker fitted with a ~2.5 millimeter (mm) sieve (Okike et al. 2015). Two fractions result: i) a fine fraction (comparatively lower in fibre and higher in energy content) and ii) a coarse fraction (comparatively higher in fibre but lower in energy content) (Figure 7). Sieving is an optional step that can be skipped when peels are to be used for ruminants which are capable of handling higher fibre material. The proportion of fine and coarse fractions can be varied by selection of appropriate sieve sizes. Larger sieve sizes result in a greater proportion of fine material.

Figure 6: Sieving pulverized cassava peel with a mechanical sieve (Photo: ILRI/Tunde Amole)



Figure 7: HQCP® fine mash (Photo: ILRI/Tunde Amole)



Drying

Fine and coarse peel mash must be dried properly for optimum storage. On sunny days, sun drying is feasible; the fine and coarse mash can be dried by spreading thinly (four to six kg/metre² (m²)) over a tarpaulin sheet, a cement slab or a metal sheet. Stirring and re-spreading of the materials is required at hourly intervals (Figure 8). To achieve appropriate moisture content (10–12%), dry the material for a period of six to eight hours. (Okike et al. 2015). On rainy days where sun drying is not feasible, the mash can be toasted in a metal pan using coal and/or firewood as a heat source (Figure 9). For production on an industrial scale involving large volumes, flash drying (which dries the material rapidly in a current of hot air or gas) is advocated although this has not been tested. Dried material should have 10–12% moisture, measured using a moisture meter, before being packed in woven plastic bags. This product can be stored safely for four to six months and used for animal feeding without any spoilage (Okike et al. 2015).

Figure 8: Sun drying (Photo: ILRI/Iheanacho Okike)



Figure 9: Toasting (Photo: ILRI/Iheanacho Okike)



Bagging and storage

The finished product is stored in woven plastic bags. The final weight for fine products is 25 kg and while the final weight for coarse products is 20 kg. An electronic scale is used for weighing bags and an industrial sewing machine is used to seal them. The practice of 'first-in, first-out' (FIFO) is advocated to ensure the older products are dispatched before newer batches. This helps to ensure that the shelf-life of the products is not exceeded. The wet cake (30–40% moisture content) can be stored in woven plastic bags for up to seven days while the dried mash (10–12% moisture content) can be stored in the bags and arranged on pallets for up to six months (Figure 10).

Figure 10: Storing of HQCP® mash (Photo: ILRI/Iheanacho Okike)



3 Processing plant components and essential machines

The equipment required for production of HQCP® mash is relatively basic in nature and essentially the same as that required for conventional garri processing. The complexity of machines varies according to the target beneficiaries and the planned production capacity size. At small- or medium-scale levels (one to three tonnes/week), the basic machinery requirements are as follows:

- Mechanized grater
- Hydraulic press
- Pulverizer
- Mechanical sieve
- Toasting pan

Other important components of the machinery include:

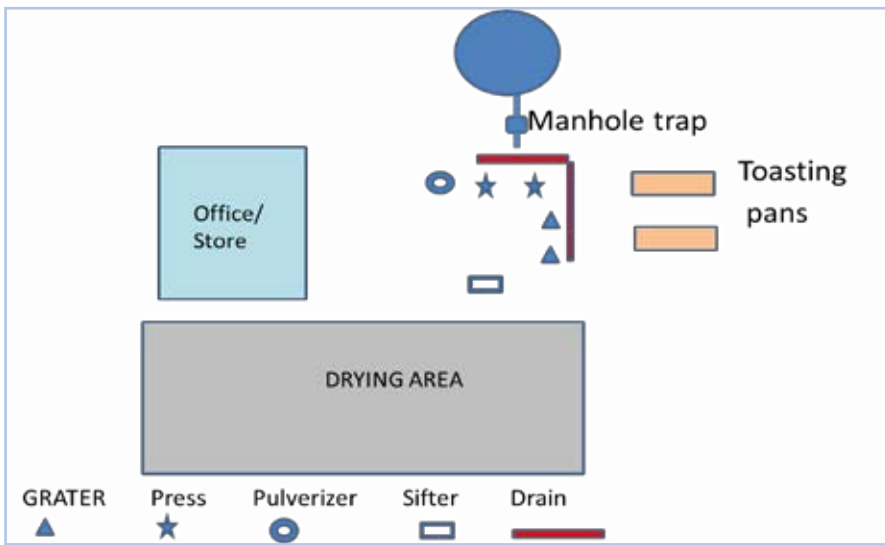
- Pressure washer
- Weighing balance (scale) (500 kg maximum weight) and locking (sewing) machine

Equipment needs will vary dependent upon production scale. At the industrial scale, the most important difference is the use of flash dryers as a replacement for toasting pans.

The wet cassava peel processing factory (Figure 13) should have the following essential areas/components:

- Core unit (peel sorting, grating & pressing)
- Toasting/drying/flash drying unit
- Soak away pit unit (disposal of drained juice during dewatering (Figures 13 and 14))
- Storage area
- Water source
- Power source

Figure 11: General Layout of processing factory



We recommend that this unit be half built from concrete to withstand moisture with large windows for ventilation and other half covered with wire mesh as shown below (Figures 14 and 15).

Figure 12: Factory prototype at Ibadan



Figure 13: Factory prototype at Niger State, Nigeria



Figure 14: Soak away pit design

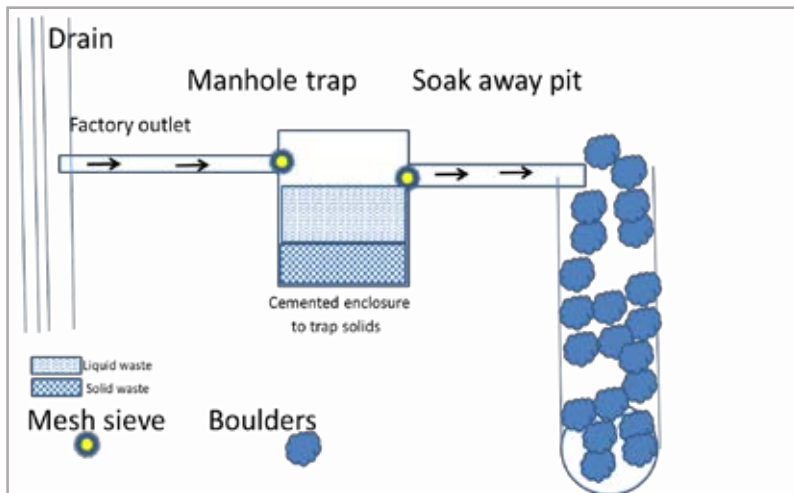


Figure 15: Clockwise from left, digging of soak away pit, filling soak-away pit with boulders, pit covered with sand, soak away pit covered with a polythene sheet (Photo: ILRI/Iheanacho Okike)



4 Nutritional quality of HQCP® mash

Several reports on the nutrient profiling of cassava peels have been published (Lukuyu et al. 2014; Oladunjoye et al. 2014; Olafadehan 2011). Cassava tubers and peel are considered good energy sources. Compared with other cereal grains, cassava is low in protein with very low essential amino acid concentrations (Olugbemi et al. 2010). As a result, cassava-based diets must be supplemented with low-cost protein sources that provide an adequate supply of methionine and lysine to make it cost effective. Adamafo et al. (2010) concluded that fermentation of cassava prior to adding it to the diet could be an alternative way of improving its protein content. However, cassava contains high levels of highly digestible starch (17% amylose and 83% amylopectin) which makes it a superior source of starch for poultry feed (Morgan and Mingan 2016). In addition, nutritional analysis of the pellets shows that it has a nutritionally similar energy value to sorghum grain (Table 1).

Table 1: Nutritional value of cassava peel pellets compared to some common grains (values generated by Near-Infrared Spectroscopy (NIRS) analysis at ILRI-India)

Sample	DM (%)	Ash (%)	EE (%)	CP (%)	ME (mj/kg)
Cassava peel (fine)	90.8	8.4	0.6	4.0	9.4
Sorghum grains	88.2	4.7	1.6	11.4	9.3
Maize grains	90.7	1.2	1.6	11.0	13.9
Pigeon pea grains	90.9	7.0	1.9	13.2	7.0
Soybean cake	91.3	3.6	7.8	53.5	10.9

Source: Okike et al. 2015

Note: DM = dry matter, EE = ether extract, CP = crude protein, ME = metabolizable energy, mj = millijoule

Handling cyanide and contamination

The presence of cyanogenic compounds in various cultivars and plant fractions has received considerable research attention compared with other chemical constituents. Nonetheless, traditional and basic processing methods for minimizing cyanide toxicity which include soaking, drying, grating and fermentation, have been found to be effective for feed across various livestock species, and can be applied with more advanced technologies for industrial commercialization of safe cassava feed/food ingredients (Tewe 1991; Tweyongyere and Katongole 2002). Sun drying alone can eliminate almost 90% of the initial cyanide content (Morgan and Mingan 2016). The innovation described in this manual combines grating, dewatering, overnight fermentation and drying as methods of elimination or reduction to an acceptable level of cyanide content in cassava peels. (Table 2).

With regards to feed safety, traditionally, it takes more than three days to dry unprocessed cassava peel due to the high-moisture content. This encourages microbial growth and proliferation, especially mycotoxin (aflatoxin) which can negatively affect animal productivity when ingested above the acceptable limit. Shortening the drying time and processing wet peels within 24 hours of peeling cassava contribute to improving product quality including ensuring that the products are well below the tolerable aflatoxin contamination limit of 20 parts per billion (ppb), particularly for poultry feeds (Table 2).

Nutritional composition of HQCP®

During development of the HQCP® mash manufacturing process, samples of HQCP® mash from three different factories in southwest Nigeria were analyzed for their nutrient profile, HCN and aflatoxin concentrations. These samples were compared with locally sun-dried cassava peels used for livestock feed from three markets and from two millers. The results of the analysis revealed the presence of aflatoxin B1 in unprocessed locally dried cassava peels slightly above the recommended maximum permissible aflatoxin level of 18-20 ppb (USFDA 2000). In addition, the HCN content is higher in unprocessed locally dried cassava peels than in the HQCP® mash, though still lower than the tolerable level (100 parts per million (ppm)).

Table 2: Laboratory results for sun-dried peels and processed cassava peel mash from various processing centres

Samples	Protein	Fat	Ash	Starch	*Aflatoxin concentrations (ppb)				HCN (ppm)
	%				B1	B2	G1	G2	
HQCP® whole	2.1	1.7	6.5	77.1	0	0	0	0	6.2
HQCP® coarse	3.1	0.8	6.4	78.1	0	0	0	0	2.4
HQCP® fine	2.6	1.0	6.4	77.7	0	0	0	0	7.6
Dried peels (Sabo)	4.0	0.2	5.89	76.8	22.0	0	0	0	13.1
Dried peels (Iloro)	3.7	1.1	5.8	74.9	19.0	0	0	0	44.6
Dried peels (Ajegunle)	4.8	0.8	5.6	80.3	22.0	0	0	0	11.1

Sabo, Ilora and Ajegunle are cassava processing clusters in Oyo State, Nigeria.

Notes: *Aflatoxin was analyzed using thin layer chromatography (TLC) with scanning densitometer. (Camag TLC Scanner 3, ISO 9001, Reg. No. 11668-01).

'Zero' means the aflatoxin level is below detection limit of the analytical method (1 ppb).

5 Good handling practices

Processing steps to ensure quality standards

Feed industries look for a standard product conforming to safety norms, free from toxins and with superior nutrient composition. This will be ensured by using fresh quality peels and applying the processing steps as set out in this manual. If fresh quality peels are used and the processing steps applied consistently, the finished products will have concentrations of HCN below 100 ppm, a level that is considered safe for feeding livestock (Lukuyu et al. 2014). Proper application of processing steps will also ensure that the finished product is free from aflatoxins and has sufficiently low fibre levels to make it suitable for the monogastric feed industry.¹

Maintaining factory hygiene

Quality depends on good practice at every stage of processing (sourcing of raw materials to dispatch of finished product from the factory). The machines and processing areas must be maintained under hygienic conditions to prevent fungal growth and buildup of waste material. All machines should be washed daily using a pressure washer after the processing activities, left clean for the following day's operations. The disposal of waste water should be through porous underground soak away pits (Figure 17).

Steps in quality assurance

Raw material procurement:

- Peels should be fresh and processed on the day of procurement
- Peels should be free from contaminants and foreign materials
- Woody tubers and roots should be discarded as they increase the amount of fibre in the finished product and can damage the grater
- Use of peels from diseased/infected tubers should be avoided

Processing and machinery specifications:

- Always follow the standard operation protocols of processing—no short cuts
- All processing machines to be kept in good working condition
- Grater/sifter- malfunction can compromise the fibre content and quality of the finished product
- Flash dryer malfunction can affect shelf life

¹ ILRI takes no responsibility for the quality of the finished product and any issues arising from feeding. Products could be tested at ILRI's facility.

Quality check of finished product:

- Physical attributes include uniform product free from contaminants—no off smell
- Chemical attributes determined by chemical analysis include moisture (10–12 %) and fibre (10–18 %)
- Below 100 ppm HCN
- Aflatoxins to check fungal load (<10 ppb for aflatoxin B1)

Shelf life and storage practices

HQCP® wet cake has a shelf life of seven days while HQCP® fine and coarse mash can be stored for up to six months without spoilage. For proper storage, the following procedures will ensure maintenance of quality during storage:

- Use pallets for proper ventilation
- Periodically check stored samples
- Practice FIFO
- Identify batches, align storage and production with market demand

6 Book and record keeping

Without good records it is difficult to assess production history and the financial condition or profitability of the business. Daily activities need to be documented in a logbook. Records should include the following:

- Record of inputs and outputs (peels, fuel, labour, electricity, finished products)
- Inventory of finished products, machines and spares
- Logbook for machine servicing and break down/repairs
- Sales and purchases

Table 3: Basic equipment and their current estimated costs as of 2018

Equipment	*Cost (USD)
Grater (with 7.5 hp motor)	1,000
Hydraulic press with 32 tonne hydraulic jack	600
Pulverizer (GX 390 engine)	850
Mechanical sieve (one tonne/day)	400
Toasting pan (one tonne/day)	550

Source: ILRI/IITA RTB Scaling Project (Unpublished)

Note: USD = United States dollar

Table 4: Key cost elements to produce one-tonne HQCP® mash (USD)

Key cost elements	USD
Production cost of cake	
*Fresh peels (dry season)	20.00
Transportation	3.00
Loading and off-loading labour	1.70
Grating	17.60
Packing into bags, loading and dewatering by hydraulic press	5.00
Cost of bags (100 reusable bags x 10 kg) for dewatering	1.00
Labour collating/loading cake	0.75
Labour for toasting (eight women/tonne output)	40.00
Cost of coal (fuel)	16.80
Packing finished products into bags and sealing	3.00
Cost of bags (40 new bags x 25 kg)	5.00
Total cost of production HQCP®	113.85
Market price for fine HQCP® mash	150.00
Market price for coarse HQCP® mash	60.00

Source: ILRI/IITA RTB Scaling Project (Unpublished); Notes: Cost covers working capital but not fixed assets.; USD 1 = 360 Nigerian Naira ; *Two tonnes of wet peels

Other important considerations

Factors to consider in setting up a HQCP® mash factory:

- Location—close to the source of raw material
- Source of power—consider the least expensive sources
- Market demand—assess prior to establishment
- Labour—consider amount of labour required and its cost

Challenges and major constraints in production and utilization of HQCP® mash:

1. Myths around HCN and aflatoxin contamination in cassava-based products still exist. Hence, there is need for more awareness and training.
2. There is a lack of a critical mass of adopters (processors) to reach benchmark minimum feed industry demand. Feed millers need a minimum quantity of guaranteed supply to enable them to change their feed formulae for reasonably long periods without being forced to frequently revert.
3. Sun drying is the lowest cost drying method, but limited volume (one tonne) is achieved daily from a drying area of 260 m².
4. High cost of initial investment is required for large scale (10 tonnes/day) to meet industrial demand. Aggregation from small- and medium-scale processors can meet demand.
5. On the technical side, cassava peels are tougher than the flesh resulting in quick blunting of the rasping drum during grating. There is the need to work with the rasping and granulometry group to develop tougher raspers for cassava peels and determine optimum particle size required for optimum moisture reduction.

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