Cassava in Tropical Africa

A Reference Manual

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

unicef
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UNIT 9

Cassava Processing

Cassava consists of 60 to 70% water. Processing it into a dry form reduces the moisture content and converts it into a more durable and stable product with less volume, which makes it more transportable.

Processing is also necessary to eliminate or reduce the level of cyanide in cassava and to improve the palatability of the food products. Processed cassava products are also used as raw materials for a number of small- or medium-scale industries in Africa.

The tubers and leaves of cassava contain cyanide which can be poisonous, depending on the levels in a particular variety. Thus, to ensure they are safe for human consumption, the cyanide must be removed or considerably reduced. According to the processing procedure used, the percentage of cyanide reduction varies from 69.85 to 100%.

The tubers are detoxified by hydrolysis of linamarin and lotaustralin into HCN (hydrogen cyanide) which is volatile and evaporates rapidly at temperatures above 28°C. Some measure of detoxification can also be achieved by mechanical disintegration (pounding, grating or chipping the tubers).

The objectives of cassava processing are to:

- reduce postharvest losses of fresh tubers
- eliminate or reduce the cyanide content
- improve the taste of cassava products
- provide raw materials for small-scale, cassava-based rural industries

Traditional methods of cassava processing

Traditional cassava processing technologies can be divided into three main groups:

- preparation of cassava chips and flour (unfermented or fermented)
- technologies based on fermented cassava dough
- minor technologies

Cassava chips and flour

Preparation of unfermented cassava flour. This process is suitable for low-cyanide cassava varieties only. The cyanide content in these varieties is 5mg or less per 100g of fresh weight, whereas in high-cyanide cassava varieties the cyanide content is 10mg or more per 100g of fresh cassava. Flour prepared from high-cyanide cassava and used for food preparations may result in acute cyanide poisoning. An example of unfermented cassava flour is 'kokonte', in Ghana.

The traditional process for preparing unfermented cassava flour is as follows:

1. The cassava tubers are peeled manually.
2. The peeled tubers are washed.
3. They are then cut into chunks (in some countries, including Rwanda and Zaïre, the peeled and washed tubers are dried as whole tubers).
4. The cassava chunks are dried on the ground (or, rarely, on elevated platforms); drying takes from 2 to 5 days, depending on the weather.
5. The dried cassava is normally stored in the form of chips in jute sacks and then sold, or it is milled for family use when necessary.

Preparation of fermented cassava flour. In Nigeria, fermented cassava flour is known as 'lafun'. It is particularly popular in the south-western states of Lagos, Ogun, Ondo and Oyo. There are slight variations in the preparation of lafun, depending on locality, but basically the process is as follows:

1. The cassava tubers are washed (in areas with water supply problems, this step is often omitted).

2. The tubers are steeped in water, usually in drums, pots or natural ponds in areas close to cassava farms. It is during this stage that the fermentation occurs. The minimum time for fermentation is 3 days; the process is slower in the rainy season than in the dry season.

3. The fermented cassava tubers are peeled. After fermentation, the peel comes off easily, as a result of partial disintegration of the cassava tubers.

4. The tubers are then dehydrated by putting them into bags and placing stones on top of the bags.

5. The dehydrated, pulverized mash is sun-dried in thin layers on mats, concrete surfaces or, very often, on rocks. Drying the mash on rocks has the advantage of allowing drying to continue overnight because the rocks absorb heat during the day and give it out at night. Drying takes from 1 to 3 days, depending on the weather.

6. The dried cassava is milled and stored for household consumption and sale.

Figure 9.1
Steeping cassava tubers for the preparation of lafun

Figure 9.2
Drying manually pulverized cassava on natural rocks

To produce better-quality flour, the tubers are peeled before steeping in water, and disintegration is carried out using a cassava grater set for larger clearance.

Deficiencies of traditional flour preparation methods. The deficiencies of preparing unfermented and fermented cassava using the traditional methods outlined above are as follows:

- Although drying the chunks or the whole tubers usually results in their outer surfaces being sufficiently dry, the moisture level inside the chunks or tubers is still considerably higher than its safe value.

- The process is quite unhygienic; spreading the product on the ground makes it vulnerable to contamination by, for example, foreign bodies or dust.

- Drying causes a major bottleneck in flour production, particularly during the rainy season when the product can become moldy and lose quality.

Fermented cassava dough

The most typical and popular product which is prepared from fermented cassava dough in West Africa is gari. Gari is a free-flowing product, consisting of cassava particles which have been gelatinized and dried. The size of these particles varies from one locality to another according to consumer preferences; a finer gari is produced by sieving the product after roasting. Gari is creamy-white or yellow, depending on the type of cassava used or whether palm oil has been added.

For good storability, the moisture content of gari should be below 12%, preferably 8 to 10%. Good-quality gari swells to about three times its initial volume when placed in water. The popularity of gari is probably based on the fact that the granules are precooked and a very short time is needed to prepare them as main dishes or snacks. An additional advantage is that well-prepared gari stores well for at least 12 months.

Traditional gari preparation. The traditional process for preparing gari is as follows:

1. The tubers are peeled manually. Usually, this is a family or group activity, with women helping each other or being hired by processors (*see* Figure 9.3)

Figure 9.3
Peeling cassava manually

2. The peeled tubers are washed (this step is sometime omitted in areas with water shortages).

3. The peeled tubers are grated. This is usually done with hand graters (perforated tin sheets, nailed to a bench or set in a frame), but mechanical graters are available and are being used in some areas (*see* Figure 9.4.)

4. The grated cassava mash is fermented and dehydrated. This is done by putting it in sacks. Logs or stones are placed on top of the sacks or, alternatively, the sacks are pressed between two boards attached by ropes; as the ropes are tightened, the water is squeezed out from the cassava mash. Fermentation usually takes from 3 to 5 days, but in localities where a bland gari taste is preferred (for example, Bendel State in Nigeria) the mash is fermented for only1 day (*see* Figure 9.5). Fermentation is very important because it gives gari its preferred sour flavor, and detoxifies the cyanide. The safe level of cyanide in gari as specified by the Nigerian Food and Drug Administration is 10ppm (1mg HCN per 100g of gari); the cyanide level for low-cyanide cassava is 50ppm (5mg HCN per 100g of fresh tubers).

Figure 9.4
Grating the tubers manually

Figure 9.5
Dehydrating and fermenting cassava mash

5. Sieves made of plant material are used to separate the gari particles and to remove fiber and poorly grated material (*see* Figure 9.6).

Figure 9.6
Sieving cassava mash

6. The particles are then ready for frying. Gari frying can be seen as two processes: starch gelatinization of the particles, and

drying. The particles are fried in shallow earthenware, aluminium or iron cast fryers (*see* Figure 9.7). In certain parts of Nigeria, an oil drum, cut longitudinally and set into a specially prepared fireplace, is used. Palm oil is added to the frying surface to prevent burning or to give the gari a yellow color. During the frying process, a calabash or a little broom is used to toss the particles.

Figure 9.7
Frying gari

7. The fried particles are cooled by spreading them on a floor; the floor is usually covered with some sort of sheeting.

Figure 9.8
Gari being sold

8. The cooled gari is sieved with locally made sieves to ensure uniformity of grain size. Large particles are normally milled and added to the sieved gari. This is then packed in polyethylene bags, jute sacks, propylene sacks or paper bags, and marketed.

Deficiencies in traditional gari production. The deficiencies in the traditional gari production process are as follows:

- Manual peeling results in low productivity. Attempts to mechanize peeling have not been successful because of the irregular shape and size of cassava tubers. However, for small- and medium-scale processing, manual peeling has the advantage of providing part-time work for women and children in rural areas.

- Grating normally results in low output (not more than 20kg of cassava can be grated per day), and may cause injuries to fingers.

- Gari fryers often have a fuel efficiency of less than 10%, and frying exposes those cooking the gari to heat, smoke and cyanide fumes.

- There is often little or no quality control of the finished product, which may result in the product having a higher moisture content than recommended, making it unsuitable for long-term storage. Sometimes, to save on fuel, gari is deliberately removed from the fryers before its moisture content has been sufficiently reduced, and then sun-dried. This practice gives satisfactory results during the dry season, but in the rainy season gari reabsorbs the moisture and becomes unsuitable for storing for more than 1 week.

Minor processing technologies

In all cassava-growing areas in Africa, starch is produced in small quantities. The process involved in starch production is summarized here:

1. The cassava tubers are peeled and washed.

2. The tubers are grated or pulverized.

3. The cassava mash is mixed with large quantities of water and sieved to extract the starch.

4. The starch granules are allowed to settle overnight.

5. The water is decanted, and the starch cake which settles at the bottom of the container is broken into pieces for drying; often it is sold as wet chunks.

6. The wet starch is sun-dried for 1-2 days.

Deficiences in traditional starch production. The problems associated with traditional methods used for starch production are as follows:

- Manual grating, especially when poor-quality graters are used, has low productivity and does not allow starch to be released from the cells efficiently.

- Sun-drying is difficult during the rainy season and often results in contamination of the finished product.

- The quality of starch depends on the quality of the water.

- There is no quality control of the finished product.

Improved cassava processing

Compared to the traditional methods, the improved method for processing cassava increases productivity and improves the quality and storability of cassava products. It also enhances the potential for cassava growers in Africa to develop non-traditional cassava products (such as cassava starch, an important raw material in the food, textile, paper and other industries; cassava flour, for use in various bakery preparations, alone or as composite flour; and cassava chips and pellets, which are incorporated in animal feed rations by EEC countries because of the low price and high energy content of cassava compared with cereals).

The objectives of improved cassava processing are:

- to reduce the drudgery and labor intensiveness of traditional cassava processing methods, and thus increase productivity

- to produce an end product of better and more uniform quality

- to ensure the reduction or total elimination of undesirable toxic constituents in cassava so that it is suitable for human consumption

- to promote the establishment of economically viable small- and medium-scale cassava-based industries and create new opportunities for employment in rural areas

- to reduce the amount of fuel used for drying cassava by introducing fuel-efficient devices and techniques

- to promote the export potential of cassava products such as starch and cassava chips and pellets

Improved cassava processing for three cassava products — gari, cassava chips and flour, and cassava starch — is presented in detail below. These specific cassava products have been selected because:

- they are relatively easy to manufacture within the existing infrastructures of the rural areas in Africa

- they could play an important role in the food security of rural communities

- the machinery required to process them is or can be manufactured by the informal engineering sectors of many African states

- they provide the raw material for a number of important industries

Gari

A flow chart depicting the improved gari processing method is presented in Figure 9.9; the moisture content of the cassava product at each stage of the process is indicated. Illustrations of various stages of the process are provided in Figures 9.10 to 9.13 (*see overleaf*).

Raw material requirements. The ratio of the fresh unpeeled cassava input to gari output is approximately 5 : 1 (that is, 2 tons of fresh cassava are required to produce approximately 400kg of gari). However, these figures are not absolute because many factors affect the ratio of output to input, such as type of cassava used, thickness of peel, age of cassava and moisture content. It is important to weigh the cassava before and after peeling.

Peeling and washing. Attempts to mechanize the peeling of cassava have not been successful because of the irregular shape

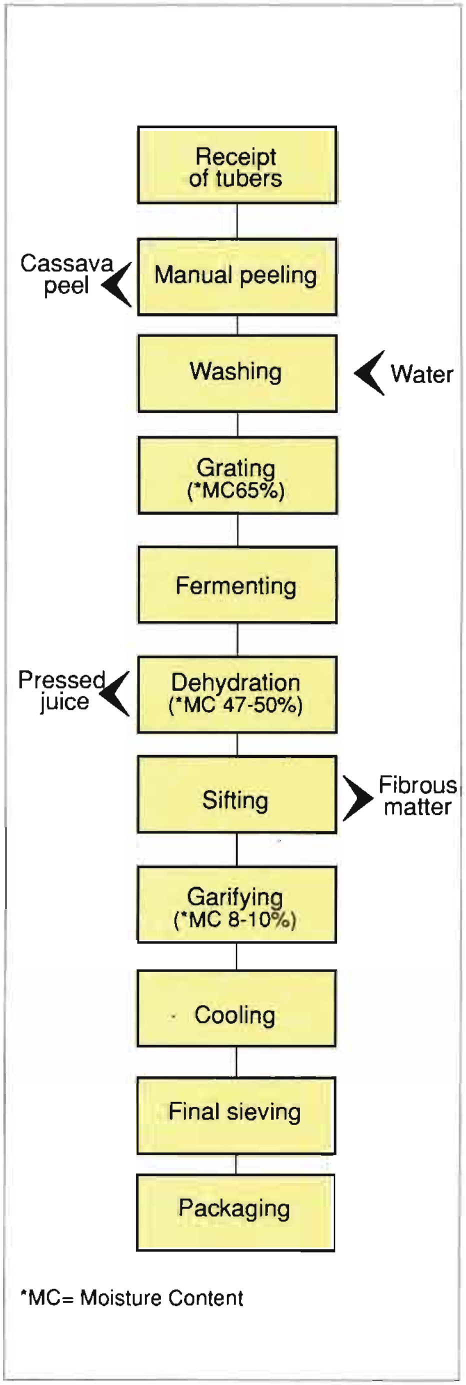

Figure 9.9
Flow chart of gari manufacture

and size of the tubers. Manual peeling with stainless steel knives is recommended.

The peeled tubers are washed and packed in woven baskets to allow the water to drain. The tanks in which the tubers are washed should be made of stainless steel, plastic or ceramic material; if these are not available, galvanized steel tanks may be used. After washing, the tanks are cleaned and dried.

Figure 9.10
Washing and grating cassava tubers

Figure 9.11
Power screw dehydrating press

Grating. The washed tubers are conveyed with wheelbarrows or other means to the cassava grater. These graters vary in size and shape but basically they all have a rotating drum covered with a perforated metallic sheet. By attaching a discharge chute to the grater, the grated cassava particles can be delivered straight into bags (made of polypropylene or other materials) for fermentation.

Fermentation. Fermentation racks are built from wood and have drainage lanes directly beneath them to allow the juice from cassava to flow out. Fermentation takes 1-5 days, depending on the preferred gari flavor in a given locality.

Dehydration. Some water drains through the holes in polypropylene bags during the fermentation stage. However, most of the moisture is removed by using power screw presses; two people operate the extension arms of the screw shaft. The moisture of the dehydrated cassava mash is 47 to 50%.

Sieving. Dehydration produces cassava cake which has to be sieved before frying. Sieving machines or sieves made of plant material are used. The cassava cake is pressed or rubbed against the surface of the sieve.

Figure 9.13
Frying gari (improved)

Figure 9.12
Mechanical sifter for cassava mash and gari

Frying. The cassava particles are fried on metal trays measuring 1.2 x 2.4m and fixed into a fireplace built of bricks or mud blocks. The fireplace has a chimney to allow smoke to escape and to improve heat efficiency. The particles are fried until crisp and dry. The recommended moisture content of the finished gari is about 10%; this can be tested with a moisture meter.

Cooling. The gari is cooled by spreading it out on polyethylene sheets on the floor. It can be cooled overnight and packed in the morning.

Final sieving and packing. The cooled gari is sieved again to ensure uniformity of the final product. It is then packed.

Cassava chips and flour

Using low-cyanide varieties. The process to be followed in the preparation of dried cassava chips and flour from low-cyanide cassava varieties is shown in Figure 9.14.

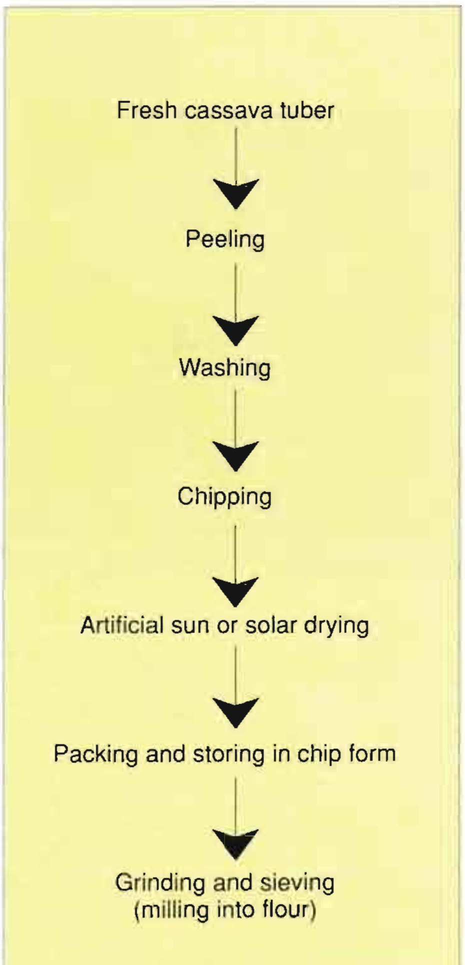

Figure 9.14
Flow chart for preparation of chips and flour from low-cyanide cassava varieties

Notes on preparation method

1. The ratio of the cassava chips output to fresh cassava input is approximately 1 : 4. Depending on the type of cassava used, 1 ton of cassava tubers gives 250kg of cassava chips.

2. It is recommended that peeling is done with stainless steel knives.

3. Peeled cassava should be washed in cemented tanks or plastic drums, to avoid adverse effects of corrosion.

4. Washed cassava may be sliced using manual or mechanical slicing machines.

5. During the dry season it is convenient to sun-dry chips on elevated platforms built in an open area, about $900m^2$. However, during the rainy season such an arrangement is not satisfactory, and some sort of enclosed drying chamber using solar energy or fuel is recommended. Drying is done until the chips have a moisture content of 8 to 10%, after which the chips are cooled and packed.

6. Cassava may be stored as chips and milled into flour when needed; chips store better than flour. There are many types of grinding machines in use in urban and rural areas in Africa.

Using high-cyanide varieties. This process for preparing cassava chips and flour from high-cyanide cassava was developed by the Ceylon Institute of Scientific and Industrial Research in Sri Lanka (*see* Figure 9.15). It removes 95% of the cyanoglucosides in cassava.

The first drying stage disrupts the cell membranes of the cassava tissue, causing increased permeability. Soaking in water results in a loss of a large fraction of soluble material, including free HCN, glucosides and cyanohydrins. By the end of the second drying stage, 90% of the HCN has been removed. Drying at 100°C causes quick decomposition of cyanohydrins and thus almost total removal of cyanide.

Flour prepared in this way can be used for various purposes (for example, in the paper industry, and in the textile industry for cotton warp sizing and textile finishing). The peels may be dried, soaked, redried, ground and used as poultry or cattle feed.

Traditionally, grinding chips into flour is done manually by pounding them in a wooden mortar. However, grinders are now common in rural and urban Africa, particularly the serrated plate type.

Notes on preparation method

1. Freshly uprooted cassava is preferred because it gives a better-quality product. However, tubers which are from 1 to 3 days old may be used if there is no obvious spoilage.

2. Chipping is done manually or with mechanically operated chippers; the thickness of slices is 4mm.

3. In the first drying stage, the sliced chips are dried in the sun for about 3 days to a moisture content of 14%. Drying is done on trays made of wood or other plant material. During the rainy season, protected solar driers are recommended.

4. The chips are soaked in water for 8 hours in tanks; a drain leads from the tank. The ratio of water to chips is 1 gallon of water to 1 pound of chips.

5. The second sun-drying stage takes 1 or 2 days.

6. Dried chips are placed in an oven at 100°C for 2 hours and dried to a moisutre content of 6 to 8%. Ovens with a capacity to dry 200kg of chips per batch and handle about four batches a day may be used.

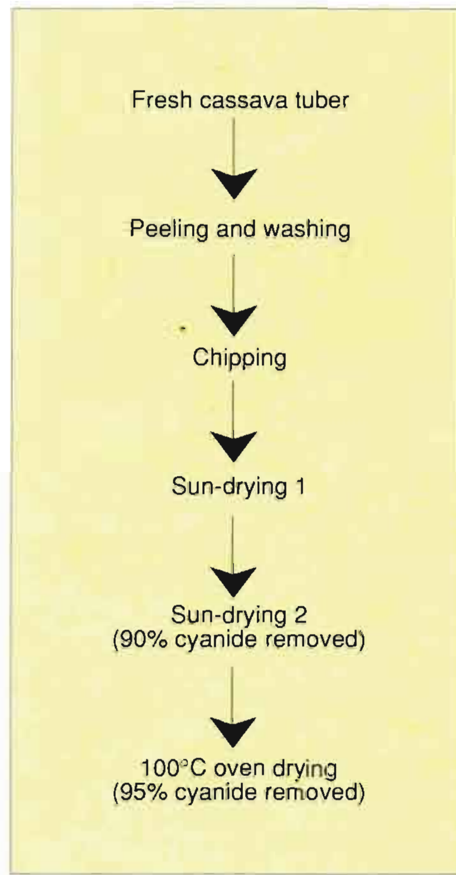

Figure 9.15
Process flow chart for preparation of detoxified flour from high-cyanide cassava varieties

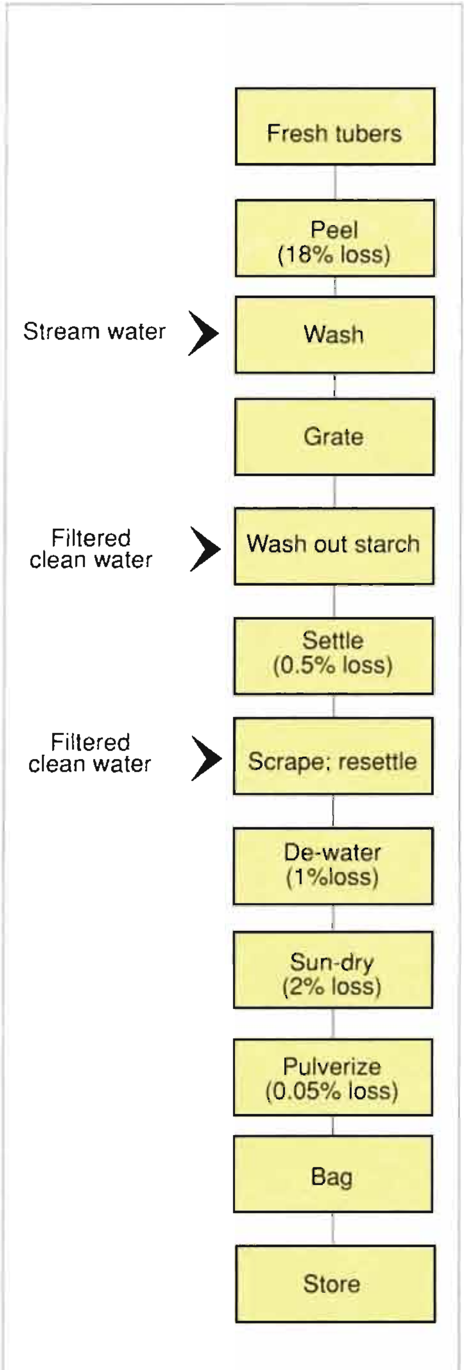

Figure 9.16
Process flow chart for manufacture of cassava starch

Cassava starch

Cassava starch is an important industrial raw material which is used in the manufacture of a number of products, including food, adhesives, thickening agents and pharmaceuticals. The process for improved starch production, shown in Figure 9.16, is very similar to the traditional process. It is based on a maximum production of 200kg/day, which is the capacity for an average rural starch factory.

Notes on preparation method

1. When selecting tubers for starch production, age and tuber quality are the critical factors. Tubers contain 20% starch by weight, but as a result of losses during processing this is reduced to 10%. Thus, 1 ton of cassava produces 100kg of cassava starch.

2. Manual peeling is still the cheapest way of peeling cassava; 18% loss of weight is assumed.

3. The peeled tubers are washed in cemented tanks. As water quality is not critical at this stage, stream water can be used.

4. Grating is important because it affects the quantity of the starch released from cassava. The percentage of starch set free is called 'rasping effect'. Its value after one rasping varies between 70 and 90%. Secondary grating using a hammer mill with a fine screen is recommended.

5. The starch is washed out using clean water. If the water contains ferrous compounds, a simple filtering system may be used. If piped treated water is available, filtering is not necessary.

   For a 200kg/day starch production, the cheapest way to wash out the starch is to use a woven basket with a piece of clean calico cloth tied around the outside. This forms a double sieve. The grated pulp is put into the basket and handwashed with water until no more milky starch comes out. The remaining pulp is discarded. The milky starch solution is collected into plastic drums (30-gallon drums are a convenient size for starch removal) and left to settle overnight.

   The discarded pulp can be fried into gari or dried and incorporated in animal feed. Gari from discarded pulp is of inferior quality.

6/7. After it has settled overnight, the clear water is drained off and the top surface of the starch cake is scraped clean; the bottom part of the cake may also need scraping. The starch is then dug out in lumps, which are again mixed with water and allowed to settle overnight. This process may be repeated the following day to get good-quality starch free of any dirt.

8. After the final settling, a clean starch cake results which is broken into small bits by hand in preparation for drying. The crumbling can be done with sieves, similar to those used in the production of gari.

9. Drying is done in ovens if the quantity of starch produced is above 1000kg per day. For small quantities, sun-drying is used. Starch is deposited on trays which are placed on racks, about 1m above the ground at an angle of about 30°. These simple measures increase the drying speed by a factor of 3. If the starch is not dry by the evening, the trays are stacked inside and returned to the racks in the morning. Solar dryers may be useful in speeding up the drying process.

   An important advantage of sun-drying is the bleaching action of the ultraviolet rays of the sunlight. The starch is dried to not more than 12% moisture content. During the rainy season, when it is difficult to sun-dry starch, it is recommended that drum dryers are used to facilitate the drying process.

Establishing a cassava-processing cottage industry

This section outlines the measures to be taken in establishing a rural cottage industry producing gari, cassava flour and cassava starch.

When deciding on the location of the industry, two important factors must be taken into account: fresh cassava tubers have a high moisture content and are therefore bulky and difficult to transport; and cassava is a highly perishable commodity. For these reasons, the industry should be located within the cassava-producing area or not more than 20km away from it; and links should be established with farms or plantations capable of supplying not less than 50% of the industry's annual raw material requirements.

A separate economic viability analysis should be undertaken for each locality before a cassava-processing industry is established.

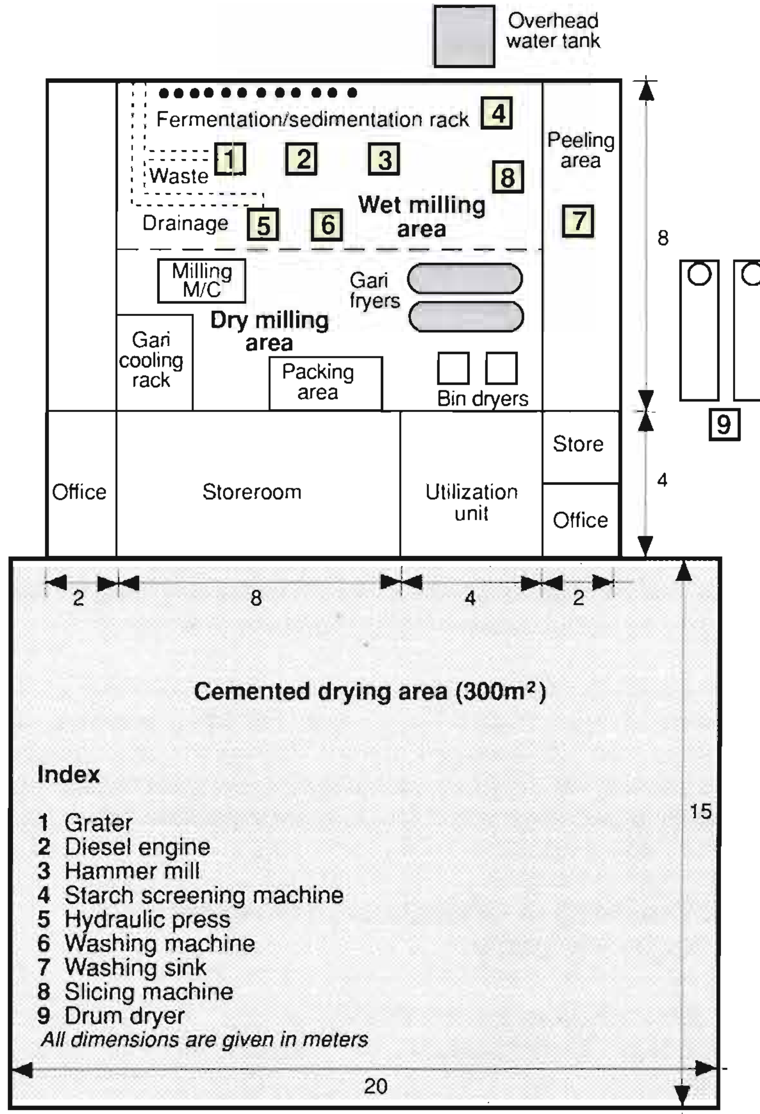

Figure 9.17

Layout of rural cassava-processing industry

The profitability of such an industry depends on many factors quite independent of its technical viability, such as government policies, supply and price of cassava, and the comparative price of the imported commodity which may be substituted.

Where a market for non-traditional cassava products has not been developed and is therefore unpredictable, it is more practical for the cottage industry to produce a few cassava products instead of concentrating on only one. This allows the flexibility to switch quickly to the product for which a market demand exists, and will also make maximum use of those implements and machines that can be used for processing different types of cassava products (for example, graters are used for both gari and starch production). The recommended output from the industry is: 400kg/day of gari; 250kg/day of cassava chips and flour; and 200kg/day of starch.

Structure and design

Figure 9.17 (*opposite*)presents the recommended layout of a rural cassava-processing industry. To reduce the cost of construction, it is an open structure, apart from the section where the finished products are stored; this area should be walled to the roof.

The dry milling area should have a concrete floor which is about 18cm thick; the floor of the wet milling area should also be concreted but about 8cm lower than the dry area. Alternatively, a cement wall about 15cm high can be built to separate the two areas.

The sink for washing tubers is 60cm deep and fitted with a tap and drainage pipe; it stands on a 60cm-high plinth. Some space is provided within the structure for stacking the starch/chips drying trays during the night. Wooden battens laid between each layer of trays allows air to circulate. The drying racks outside are made of bamboo poles. The center pole is about 10cm higher than the others to provide the necessary tilt.

Machinery and implements

The type and quantity of implements and machinery required for a rural cassava processing industry are given in Table 9.1 (*see overleaf*).

Machinery for processing gari. The gari-processing machinery itemized in Table 9.1 is described here, apart from the petrol and diesel engines.

Cassava grater

The cassava grater (stationery or mobile) has become a permanent feature of cassava processing in rural communities. These graters can grate at least 4 tons of fresh tubers per day, and thus only one is needed to handle all the gari/starch processing operations of a rural industry.

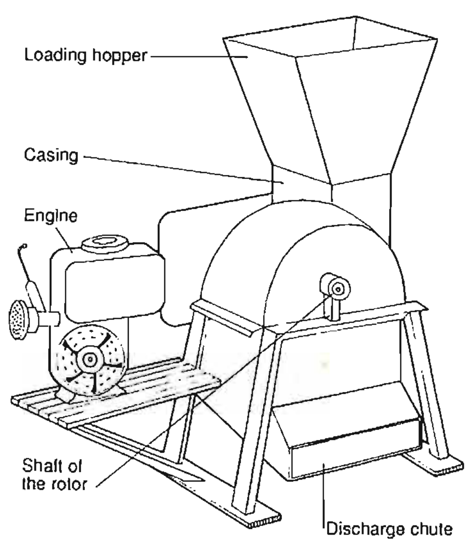

Figure 9.18
A typical cassava grater

Table 9.1

Machinery and implements for rural cassava-processing industries

Item	Quantity	Description
Machinery for gari		
Cassava grater*	1	Powered by 5hp diesel engine
Cassava press	1	Output 500kg/hr; manually operated
Diesel engine	1	Screw type; 5hp
Sieving machine	1	Powered by 3hp petrol engine
Gari fryer	2	200kg/day capacity
Petrol engine	1	3hp
Machinery for cassava chips and flour		
Slicing machine	1	300kg/hr
Dryer	1	Bin type; 200kg/day
Milling machine	1	5hp engine 500kg/hr
Machinery for cassava starch		
Drum dryer	2	50kg/hr
Implements and accessories		
Knives (for peeling cassava)	20	Stainless steel
Plastic drums	30	For fermentation
Fermentation racks		Made of wood
Drying trays	100	Made of local wood and plastic net; 0.7x 1.0m
Basket for sieving starch	10	Local type
Moisture meter	1	Multipurpose, suitable for grains and flours
Weighing scale	1	For fresh cassava up to 200kg
Weighing scale	1	For finished product up to 10kg

Note: The cassava grater is used for both starch and gari production

A typical cassava grater incorporates a cylindrical, rotating, wooden drum which is covered with a nail-punched metal sheet (galvanized or tin), as shown in Figure 9.18. The rotary drum is set into a casing, with the critical dimension being the clearance between the lower part of the drum and the casing; this clearance determines the size of the grated particle.

The output of the grater varies from 500kg to 1000kg per hour, depending on the diameter and speed of the rotary drum and the number of perforations per unit area of the drum surface; these parameters have not been standardized.

When selecting, installing and using the grater, it is important to ensure that:

- the grating surface is constructed from non-corrosive material
- the perforated grating surface is easily replaceable when it becomes worn
- the grater is built on a platform so that the cassava mash can be easily and hygenically discharged directly into a fermentation sack or container
- there is little or no contact between the expressed cassava juice and the wooden drum of the rotor (otherwise, the drum will deteriorate fast and bits of wood will get into the cassava)
- the grater is thoroughly washed after each day of operation to ensure long-term use and hygenic processing

Dehydration press
The most durable and convenient dehydration press for small-scale production is the power screw de-watering press (*see* Figure 9.11). The dehydration press incorporating a hydraulic jack (*see* Figure 9.19) is faster and less labor intensive; however, the seals wear out rapidly, and replacing them may be difficult. The cassava juice expressed during this operation can be collected for starch.

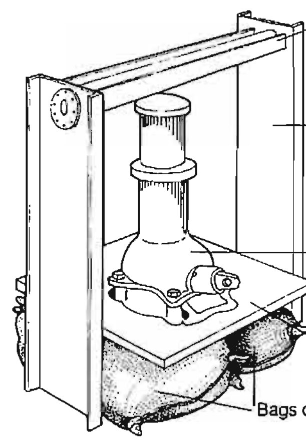

Figure 9.19
Hydraulic jack press

Sieving machine
Cassava particles are always sifted before and after the garifying (frying) operation. This can be done easily with a sieving machine powered by a 1.5kw electric motor or diesel engine (*see* Figure 9.12). The sieving trays have holes of different diameters, so that the machine can be used for sieving both uncooked and fried gari particles. However, sieving raw cassava particles is better done by feeding the cassava cake back into the grater after dehydration (*see* Figure 9.18).

In the absence of a sieving machine, a manual bamboo sieve (300-400 microns in sieve size) can be used.

Gari fryers
Many types of gari fryers, both mechanized and manually oper-

ated, have been developed in West Africa. The most cost-effective type in industries producing less than 500kg of gari per day seems to be the RAIDS gari fryer (*see* Figure 9.20). It consists of a rectangular tray set into a brick fireplace with a chimney. The tray is made of 3mm-thick mild steel sheets and has a side opening for discharging the finished product. To produce 400kg per day, two gari fryers are required.

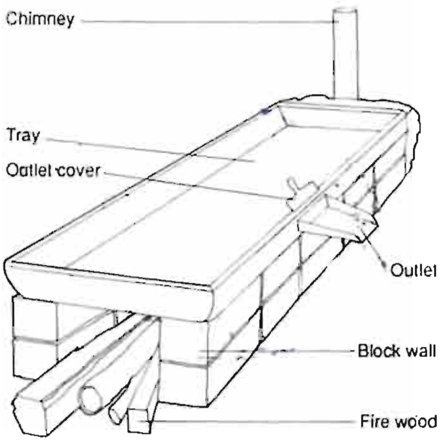

Figure 9.20
RAIDS gari fryer

Machinery for processing cassava chips and flour. The three items required for processing cassava chips and flour are a slicing machine, drying equipment (for natural or artificial drying) and a milling machine.

Slicing machine

A mechanized or manually operated slicing machine (*see* Figure 9.21) is an important investment for producing cassava slices of uniform thickness to ensure more uniform drying. It will save time and energy, improve productivity, increase the surface area available for drying and produce better-quality chips and flour.

Slicing machines are popular in Asia but uncommon in West Africa. The type used in Asia consists of a steel framework supporting a feed hopper, a casing containing the rotor disc and a petrol/diesel engine. The cutting drum is fitted with four blades which rotate at about 500rpm. The size of the cassava chip is 10cm x 10cm x 50cm; the optimal thickness of the chip is 6mm for through-flow drying and 10mm for cross-flow drying. The machine produces 1 ton of chips per hour, and a single machine is adequate for a rural cassava-processing industry.

Figure 9.21
Manually operated slicing machines

Dryers

Drying is carried out to reduce moisture content and is essentially a process of simultaneous heat and moisture transfer. Heat is required to evaporate the moisture from the inside and the surface of a product by an external drying medium, usually air. In a number of agricultural crops, including cassava, the drying of single particles under constant external conditions exhibits a constant-rate moisture loss during the initial drying period, followed by a falling-rate moisture loss. This implies that the drying rate decreases continuously during the course of drying.

Drying methods can be classified as natural or artificial.

(a) In natural drying, the material is subjected to the combined action of sun rays and atmospheric air. Natural drying can be divided into three categories: sun drying, solar drying and natural ventilation.

- Sun drying. This is the most common method of drying in Africa. The material is spread on the ground, roof top, compacted soil, concrete floor or, more rarely, on an elevated platform. The material is occasionally turned. There are numerous disadvantages to this method, such as reabsorption of moisture from the ground, uneven drying, insect and animal invasion, and exposure to dirt and dust.

- Solar drying. Sun drying can be speeded up through the introduction of solar dryers to enhance the effect of solar radiation. Solar dryers can be simple box structures covered with polyethylene sheets, plastic sheets or complex structures which incorporate blowers and transparent plastic sheets.

- Natural ventilation. Agricultural crops are sometimes put onto platforms where they are allowed to dry by natural air. The downward flow of air is increased by placing a windbreak in front of the platform.

(b) Artificial drying methods are those which use blowers, heaters and other external energy sources. In areas where solar radiation and relative humidity are conducive to sun-drying, sun-drying should be encouraged. Artificial methods should be used only as a supplement to sun-drying during the rainy season or during the night or early morning. The three methods of artificial drying described here involve the use of drying trays, artificial forced circulation dryers and solar dryers.

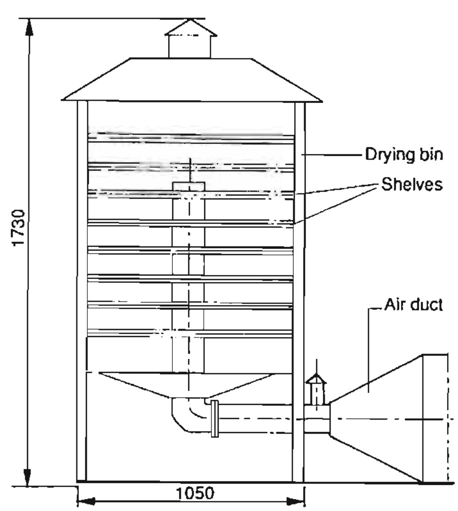

Figure 9.22
Multipurpose bin dryer

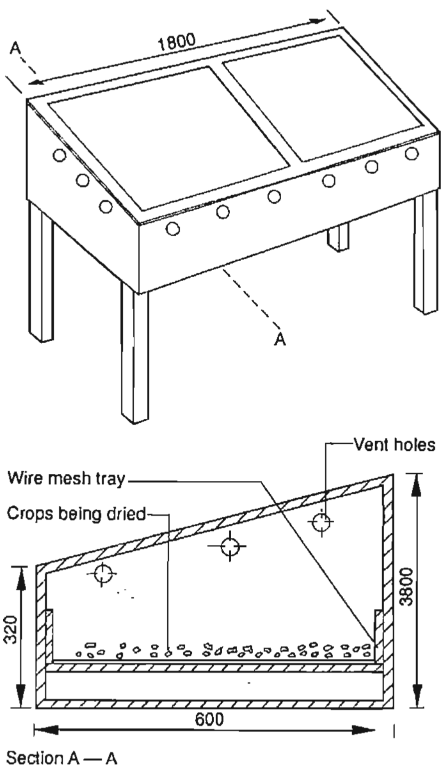

Figure 9.23
Cabinet dryer, showing cross-section (below)

- Drying trays, measuring 0.7 x 1m, can be made of plant material, but investing in more durable plastic mesh/ netting or wooden trays is more cost-effective in the long run. The chips are laid on the trays (about 10kg per square meter); the trays are placed on specially built racks inclined at a 25 to 30° angle. The number of trays needed depends on the rate of production of the chips.

- During the rainy season, when it becomes impossible to dry cassava chips outside, artificial forced circulation dryers can be used. A suitable design is shown in Figure 9.22 (*on page 107*). The drying chamber is made of plywood, and the product to be dried is arranged on the shelves. The air is blown by a centrifugal blower into a heat exchanger which consists of a series of pipes set in a fireplace with a chimney; the blower is driven by an electric motor or a small petrol engine with a power of 0.7 to 1.0kw. The air is heated by the pipes and passes into the drying chamber; here it picks up moisture from the product and escapes through the opening at the top of the drying chamber. About 500kg of cassava chips with a moisture content of 12% can be dried in 40 to 48 hours. The blower is driven by an electric motor or a small petrol engine with a power of 0.7 to 1.0kw.

- Solar dryers, such as the cabinet dryer shown in Figure 9.23, can be constructed from locally available materials. They enhance the insulation effect and contribute towards the generation of higher air temperatures and lower relative humidities, both of which are conducive to improved drying rates and lower final moisture content of the dried crop. The higher temperatures also deter insect and microbial infestation.

Milling machine

The most common type of mill used in Africa for grinding chips into flour is a plate mill. This has stationary and rotating serrated plates. The clearance between these plates regulates the degree of fineness of the milled product. The output of the milled material depends on the size of the plate and the power of the motor or engine.

Another type of milling machine, the hammer mill, has a series of reversible, flexible hammers fixed radially inside the casing (*see* Figure 9.24). The material is fed through the hopper, and moved over the wire mesh screen by the hammers; the size of the milled particle is regulated by the screen.

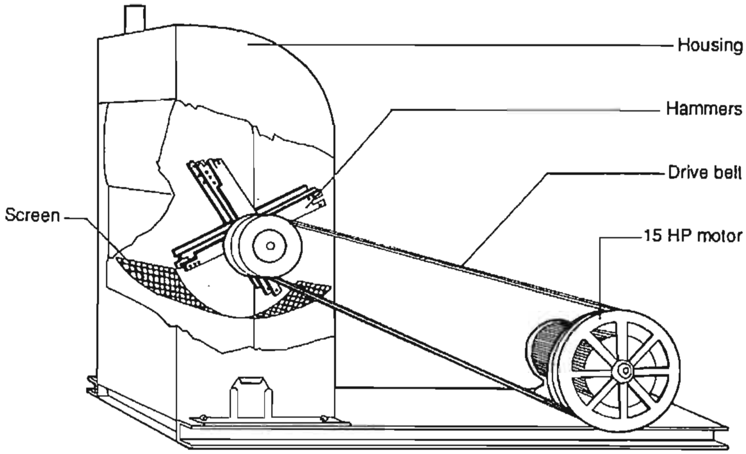

Figure 9.24
Hammer mill

Although the hammer mill uses less energy to produce the same output as that produced by the plate mill, it is not as suitable for small-scale rural cassava-processing industries as the plate mill because:

- the availability of spare parts for the hammer mill in most cassava-growing areas in Africa is limited (for example, it is necessary, to replace the screen regularly, and obtaining a new screen often poses problems)
- it can be used only for dry material, whereas the plate mill can be used for grinding both wet and dry material

Machinery for processing starch. The Brook dryer is a simple device which consists of three 200-liter drums and a screen. The drums are laid end to end and are joined together, as illustrated in Figure 9.25. Above the drums is the screen. A fire is built in the first drum, and the warm air from the fire passes through the starch.

After being dried in the Brook dryer, the starch is ground in a plate mill and is then sieved. It is necessary to sieve the starch because the standard particle size for starch used for most applications is very small. However, if the demand for cassava starch increases, it may be necessary for the rural industry to invest in pulverizing equipment.

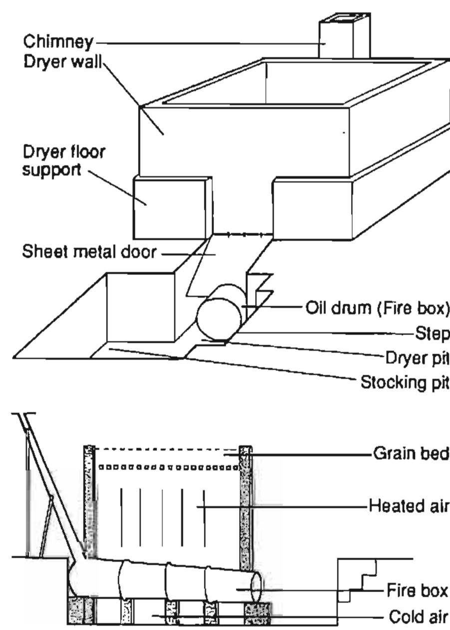

Figure 9.25
Brook dryer, showing cross-section (below)

Packing and storage

A number of African research institutions, including the Nigeria Stored Products Research Institute (NSPRI), have analyzed the suitability of locally available packaging methods for long-term storage of processed cassava products.

The most cost-effective storage measures are outlined below.

- Ensure that the product to be packaged is dried to a safe moisture content. The amount of moisture in an agricultural crop or product is the most important factor determining its storability. When determining the moisture content, it is important to ensure that:

  (a) the sample is representative of the batch which is being examined and the samplings are sufficiently large

  (b) the sample is kept in a sealed container before determining the moisture content

  The amount of moisture in a sample of produce which does not decompose when the produce is heated can be determined by weighing some of the ground produce and then drying it in a forced draft air oven at a given temperature for a predetermined length of time. The drop in the weight of the produce is measured according to its initial weight (wet basis).

- Allow the product to cool sufficiently before packing it. Latent heat which is not released will later condense inside the sealed container, resulting in mold growth and insect development.

- The material which has been prepared according to the procedure described above can be stored in polyethylene-lined sacks or brown paper bags in quantities of about 25kg or more for at least 12 months. If the material is to be packed into smaller packages (in quantities of 2, 5 or 10kg), thick polyethylene bags with a gauge of at least 0.15mm should be used. The larger bags are tied with a piece of string, while the smaller bags are sealed.

  It is important to note that if the moisture content of the flour or gari is not sufficiently low and the product is not intended for long-term storage, polyethylene or hessian sacks provide better conditions for short-term storage.

- Cassava chips store better than cassava flour. If flour is required, the cassava should be stored as chips and then milled into flour just prior to sale or immediate use. Cassava flour, like gari, can be stored in polyethylene or paper bags, as described above.

- A fumigant, in the form of a tablet, should be put inside the bags. Phostoxin is safe as long as the user follows directions for its use provided by qualified agricultural extension personnel.

- Measures to control rodents by mechanical or chemical means must be applied.