PRIMARY PROCESSING

Food and Agriculture Organization of the United Nations

PRIMARY PROCESSING

1.- General information

The most important root crops in terms of production tonnage in developing countries are cassava, potato and sweet potato.

Root crops are a cheap, readily available energy source for many people. They contain very little protein or fat, but some (sweet potato and yam) are a good source of vitamins A and C. Roots are tubers are not consumed raw as the starch is not digestible.
Therefore, they all require some form of primary processing to make them edible. There is also a range of value-added products that can be made out of roots and tubers.

All root crops are bulky and perish relatively quickly. This means that they cannot be stored for long periods or transported over long distances. Processing removes the water which reduces the bulk and also increases the storage life.

The methods of processing and cooking range from simple boiling to elaborate fermentation, drying and grinding to make flour, depending on the varieties of roots and tubers.

- Roots and Tubers -

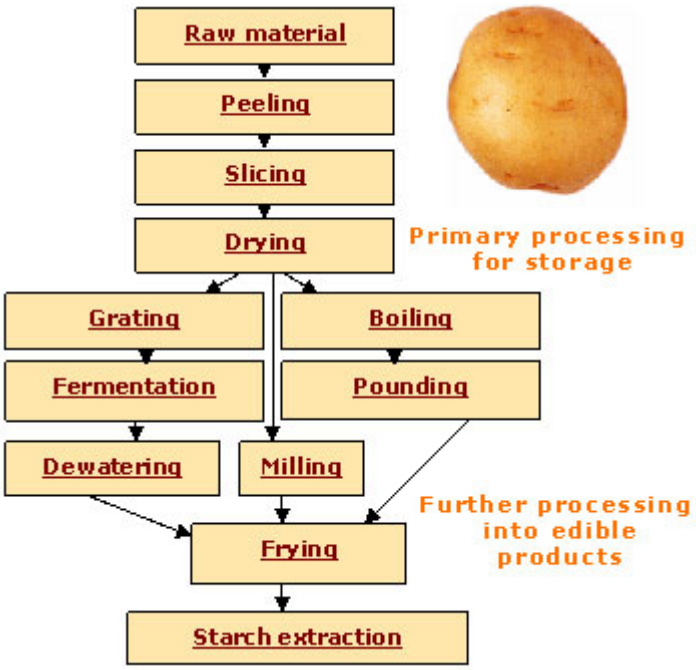
Cassava. Many varieties of cassva contain toxic cyanide compounds which have to be removed before consumption. Various processing methods are used to detoxify the roots and to transform the cassava into a range of products. It is usually dried and made into flour which can be used in bread making, or fermented and roasted to make gari. It is also made into starch and beer.

Sweet potato. The majority of sweet potato is processed into starch that is used for the preparation of transparent noodles. It is also dried to make a flour that is used in bread making and as a stabiliser in ice cream. Sweet potatoes are also fried to make potato chips or crisps which are a popular snack food.

Potato. Dried potato (papa seca) is a popular way of preserving potato in the Andes. Fried potato crisps/chips are a popular snack food.

Banana and plantain. Dessert varieties of banana can be eaten raw, but green banana and plantain need cooking or processing prior to eating. Green banana is dried and made into a flour. It is also fermented and made into beer.

2.-Primary processing of roots and tubers



2.1.-Preparation of raw material

Root crops are mainly composed of starch, but also contain minor components, some of which are beneficial and others which are not.

Many roots contain small amounts of the enzyme polyphenyl-oxidase. This enzyme is responsible for the darkening of fresh cut surfaces of the root when they are exposed to air. The activity of the enzyme can be inhibited by blanching the roots prior to processing. This procedure needs to be taken into consideration when processing roots and tubers.

Some root crops contain toxic substances. The most important one is cassava which contains cyanide compounds. Some varieties of potato contain solanins. It is essential that these roots and tubers are made safe to eat by processing.

Roots should be washed to remove soil and other dirt. Damaged or diseased roots should be discarded. Equipment is available for washing and peeling roots and tubers. However, it is sometimes too expensive for small rural businesses.

Washing machines are usually made of a cylinder that is fitted with paddles and brushes that can be rotated while a stream of water is passed over the crop as it passes through the washer.

2.2.- Peeling

Roots and tubers are peeled to remove the inedible outer layers. Peeling is traditionally carried out by hand, although mechanical peelers are available.

Lye peeling is an effective way of peeling roots and tubers.

The food is placed in a hot solution (at or near boiling point) of sodium hydroxide for a specified time which varies, according to the type of vegetable. The loosened skin is removed by jets of water. Care is needed as hot lye is very dangerous and corrosive to some metal equipment. Lye peeling is often combined with blanching in one operation.

Mechanical peelers operate by rubbing the roots against a rotating abrasive surface. They are best suited to raw materials of a regular shape. Irregular shaped materials have high peeling losses or require hand peeling to finish them off.

The use of mechanical peelers is dependent on the throughput required and the cost of the machine versus the wages for peeling by hand.

2.3.-Slicing

The peeled roots are sliced or chipped before drying. This exposes more surface area to the air and speeds up the drying process.

Slicing root crops prior to cooking is also important as it allows more rapid and even cooking.

Traditionally roots are sliced by hand. A range of mechanised chipping and slicing machines are available.

2.4.-Drying

Root crops have a high moisture content. Reducing the amount of water by drying is a simple way of extending the storage life of roots and tubers.

There are two stages in the drying process:

1. Removing surface water

2. Removing internal moisture from within the material

The relative humidity of air decreases rapidly as its temperature is raised and at the same time its water-absorbing capacity increases.

The rate of drying during the first stage is dependent on the ability of the air passing over the material to absorb and remove moisture.

Air flow rate is more important than temperature. However, in areas of high humidity the air may need heating to lower its humidity to a level that allows it to absorb significant amounts of water. In general, air with a relative humidity of 75% or more is not effective at drying, except at the earliest stages when the root is very wet.

The surface area of food exposed to the air is also very important. Slicing or chipping the root crop will increase the surface area and thereby reduce the drying time.

Once the surface water is removed, the second stage of drying begins where water is removed from the interior of the material.

The rate of drying in the second stage is dependent on the rate at which moisture can pass through the tissue to the surface where it evaporates into the passing air.

The passage of water from the inside to the outside is a slow process so drying rates are lower than in the first stage of drying. The drying rate is dependent on the moisture content and on temperature rather than air flow.

A range of driers are available, ranging from solar driers through kiln driers and forced air driers. The selection of drier depends on the cost of the drier and the value of the product being dried. Traditionally, high-tech driers are not used for root crops. This is because root crops and their products are fairly low value foods and the use of a drier would not be economically viable.

2.5.-Grating

Grating the root into fine shreds is a common step in the processing of many root crop products. It helps to facilitate later steps in the process, for example de-watering, drying, fermentation or pulping.

Grating alters the texture of the raw material. It is an essential step during cassava processing as it allows for fermentation of the material and the breakdown of cyanide containing compounds.

Grating is time consuming and hard work. A range of simple hand held and mechanical graters are available. Many graters are based on a rotating horizontal disc or a vertical drum grating surface against which the root crop is held.

Low-cost hand graters can be made from a sheet of tin or galvanised mild steel. The grating surface is made by puncturing the surface with holes. The grater can be held horizontally in a frame or downwards.

2.6.-Boiling and steaming

Root crops are often cooked by boiling or steaming, either for direct consumption or as a step in a processing system.

Boiling and steaming does not preserve the crop. It needs further processing for preservation.

Boiling and steaming are important in cassava processing to detoxify the material.

2.7.-Fermentation

Fermentation is the most important step during the processing of cassava and high-alkaloid varieties of potato. It results in a decrease in the level of toxic compounds.

In cassava processing, there are two methods of fermentation - wet and dry methods.

The dry method is used in the production of gari and is carried out in the presence of air. The grated cassava passes through a two-stage fermentation.

During the first phase, starch is broken down and acids are produced. Enzymes contained in the root start to break down the cyanide compounds and release hydrogen cyanide gas.

At the end of the first stage, the conditions are just right for the growth of a range of micro-organisms that ferment the gari to give it the characteristic flavours.

Most of the cyanide is lost during the fermentation, but any remaining is driven off during the subsequent roasting step.

The wet method of fermentation is sometimes referred to as retting. It takes place in the absence of air. Cassava roots (either peeled or entire) are soaked under water for several days until they have softened. The material is then broken up, sieved and the water squeezed out.

The wet fermentation of cassava makes a product with an unpleasant odour. It also produces a lot of water that can be difficult to dispose of.

2.8.-Pounding

Pounding changes the texture of the previously prepared root crop into a more paste-like consistency. The root is first peeled and softened by boiling or soaking.

Traditionally material is ground using a large pestle and mortar.

Pounding of fufu from yams and cassava to make a gelatinous sticky product can take up to one hour using a mortar and pestle.

Pounding machines are available, but hand pounding is often preferred as it gives the product a superior taste.

2.9.-De-watering

De-watering or pressing is a process that can remove up to 50% of the water present from the root crop.

The process is most common in cassava processing where it is an important method or reducing toxicity. Traditionally heavy weights are placed on the prepared crop to press out the liquid, which drains away. There are several press designs available, ranging from the simple easily constructed parallel press to the more sophisticated screw press or hydraulic press.

Screw presses can be made from a circular press cage that holds the pulp or a square press frame into which sacks of pulp are placed. A heavy weight is lowered and raised by a screw thread to press the pulp.

Some presses are made using hydraulic car jacks to apply pressure to the material that is being pressed. Care is need to prevent leakage of poisonous hydraulic fluid from the jack.

2.10.-Grinding, Milling, Sieving

After roots have been sliced and dried, most can be ground into a flour. Cassava is the most commonly processed in this way, where it is used to prepare fufu.

Traditionally, dried pieces of root are ground in mortars and pestles.

For larger scale use, a range of manual or powered plate and disc mills are available.

Lumps often occur in gari if it is not heated evenly during roasting.

The lumps can be broken down into finer particles by passing the roasted cassava through a hammer mill or plate mill.

After grinding the flour is sieved to remove large particles, which are returned to the mill for further grinding. Sieving can be mechanised by using a vibrating or rotating sieve.

2.11.-Frying and roasting

Many root crops are prepared by frying in hot oil or roasting. Both frying and roasting enhance the flavour of the root crop and reduce the moisture content, thereby extending its shelf life.

Roasting is an important stage during the production of gari from cassava. The heat applied burns off the cyanide gas. It also partially gelatinises the starch.

Gari is traditionally heated in shallow cast iron pans over a fire while being pressed and stirred against the hot surface to prevent burning.

Roasting can be mechanised by making a cylindrical drum roaster.

2.12.-Starch extraction

Starch can be extracted from any root crop. However, the two most common are potato and cassava. Industrially, starch is extracted by a combination of wet milling, sieving and settling.

Starch can also be extracted more simply, by collecting the liquid that drains off during pressing and allowing the starch to settle out.

3.-Cyanide in cassava

Most varieties of cassava contain compounds (glycosides) that contain cyanide. They must be processed to remove the cyanide before consumption. A few 'sweet' varieties contain no or very low levels of the compounds and are sometimes eaten raw or with minimal processing.

Peeling the roots reduces the level of toxicity since many of the glycosides are contained within the peel and outer layers of the root.

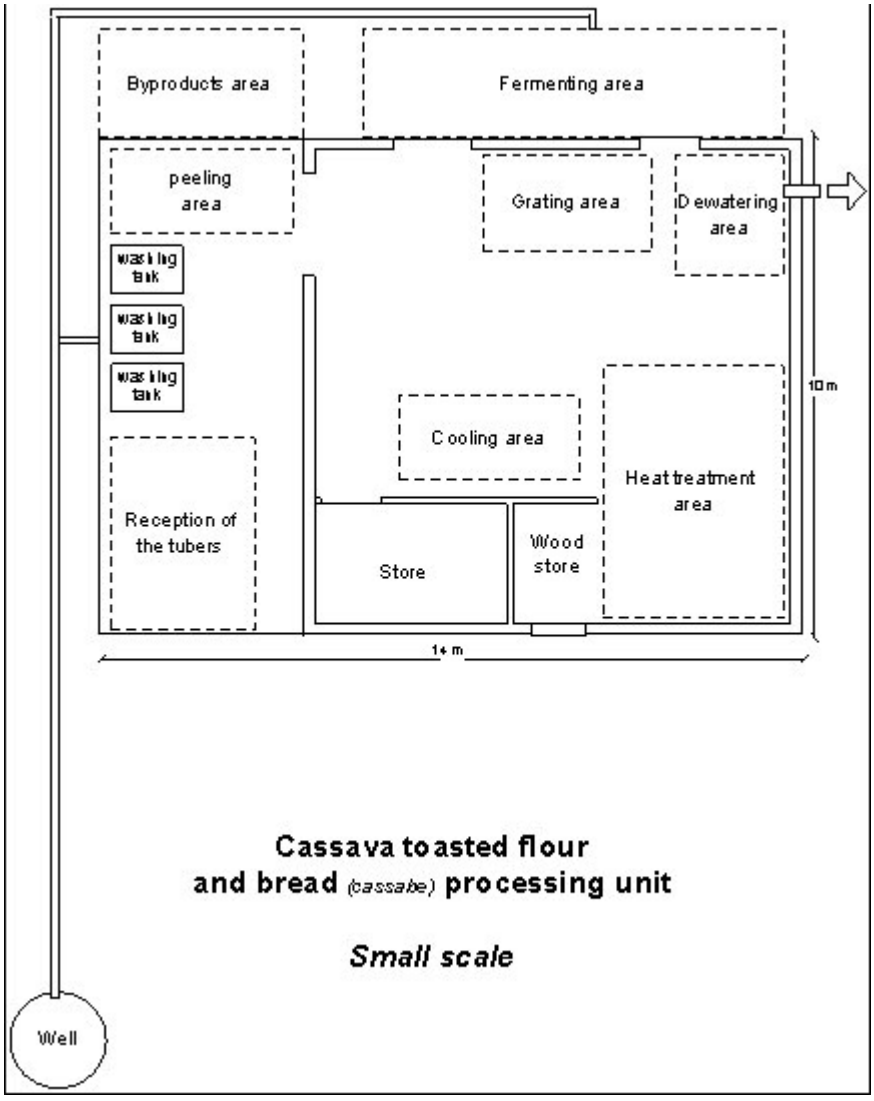
After peeling, the roots are grated which breaks down the internal cells and releases an ezyme that breaks down the cyanide glycoside complex. This releases hydrogen cyanide gas. The grated cassava is then fermented (using lactic acid bacteria).

The acidic conditions of the fermentation further break down the cyanide glycosides. When this is complete, the cyanide gas is evaporated by heating the cassava, either by frying, roasting or boiling.

The detoxified product can be dried and ground into a flour or used to make gari and other products.

PROCESSING UNIT

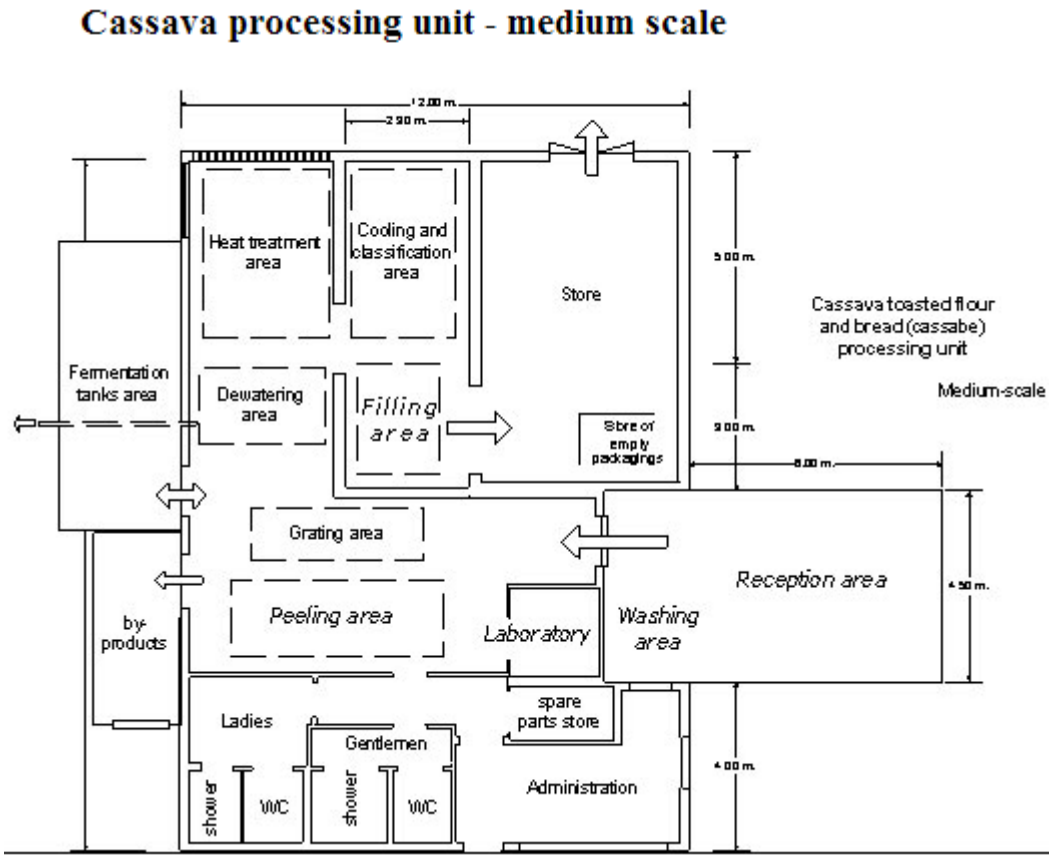
Small scale



Cassava toasted flour and bread *(cassabe)* processing unit

Small scale

Medium scale



- Operation: Pack/Seal –

Prices Codes	Cost ($US)
1	0-170
2	171-850

° Suppliers of packaging equipment

Equipment cathegory	Scale	Name of the equipment	Technical description	Price Code	Ref	Images
Plastic	S-M	polythene heat sealer	This sealer is used for sealing packaging. The thermostatically-controlled heater bar has a maximum sealing length of 20.3 cm. The machine is pedal operated for bench mounting and power consumption is 0.25kW. A similar version, the HM 201C is suitable for cellulose films.	1	2	
	S-M	impulse heat sealer	Two models are available: the HM 1300 with a maximum sealing length of 33cm; and the HM 1800 which has a maximum sealing length of 45.7cm. The machines are bench mounted and are available with single or dual electronic time control.	2	2	

	S-M	dapper plastic bag and heat sealer	This is capable of sealing polythene, polypropylene, coated aluminium foils and cellophane laminates. It can be foot- or hand-operated. Once plugged in, the electrical current (230V) only passes through the element when the jaws of the machine are closed. A roll holder and adjustable bag support are available as optional extras. 25cm and 61cm models are also available.	2	2	
	S-M	bar type impulse heat sealer	This simple machine seals plastic bags by pressing the plastic between heated bars, on which a special tape is placed to prevent the plastic burning. It is designed to use electricity, but alternative sources can be used for heating the bar.	2	2	
	S-M	hand/pedal operated sealing machine	Designed for small scale production, this has a timer for sealing different thicknesses of film (up to 500 gauge) and different plastic materials. A buzzer indicates when the sealing operation is completed. Throughput: 1000 bags per shift. Size range: 20cm, 30cm and 46cm.	1	2	
	M	carton packaging equipment	To hot fill juice and to automatically form, fill and seal various sizes (0.25, 0.5 and 1 litre) of plastic coated paper board gable top cartons. Capacity 2-100 cartons per minute.	4	29	
	S-M	electric polythene bag sealing machine	This machine is foot operated and incorporates temperature as well as impulse control (to avoid burning of bags).	1	29	
	S-M	manual heat sealing machine	Used for sealing plugs of plastic containers, bottles, jars and jerrycans.		29	
	S-M	plastic film heat sealing machine	This machine is foot operated. Capacity 120 bags per hour.	1	29	
General	M	packaging machines	Packaging machines such as heat sealers, carton sealing machines, stretch wrapping machines, case packers and palletisers.		29	
	M	packaging equipment	Used for packing food in powder, grains/granules and liquid form. Vertical and horizontal heater. The equipment can be used with many kinds of materials as well as sizes of package: 150-350mm/length; 130-250mm/width. Capacity 20-50 bags per minute.	3	29	
	M	filling and packing machines	A range of fillers for bottles, cups and cartons; sealing and capping systems.		29	
	S-M	semi automatic labelling machine	Suitable for all types of round containers, jars, tins, cans and bottles.		29	
	S-M	label gumming machine	This hand operated label gumming machine is suitable for labels of up to 15cm width.		29	

Suppliers of packaging material and equipment

TPI Technico Plaste Industrie	Benin
Fabasem	Cameroon
Helepac	Cameroon
Papier Plus	Cameroon
Plasticam	Cameroon
Printpak	Cameroon
Ghana Carton Boxes Mfg Ltd	Ghana
Plastics Packaging Products Ltd	Ghana
Top Industrial Packaging Products Ltd	Ghana
Tropical Glass Co Ltd	Ghana
John Kojo Arthur	Ghana
Sada-SA	Mali
Mark Industries (PVT) Ltd	Bangladesh
Bajaj Maschinen PVT. Ltd.	India
Bhavani Sales Corporation	India
Gardners Corporation	India
Geeta Food Engineering	India
Gurdeep Packaging Machines	India
M.M.M.Buxabhoy & Co.	India
Narangs Corporation	India
Orbit Equipments PVT. Ltd.	India
Pharmaco Machines	India
Rank and Company	India
Sridevi Packing Industries	India
Sunray Industries	India
Techno - Equipments	India
Banyong Engineering	Thailand
ALFA Technology Transfer Centre	Vietnam
Technology & Equipment Development Centre (LIDUTA)	Vietnam
Charles Wait (Process Plant) Limited	UK
Packaging Progress	UK
Industrias Technologicas Dinamicas S.A.	Peru