



CASSAVA PROCESSING

Introduction

Cassava is a staple crop and is particularly important in Africa and South America. It is a perennial shrub that grows to approximately 2 metres tall and has the ability to grow on marginal lands in low-nutrient soils where other crops do not grow well. It is also fairly drought tolerant.

It is grown for its enlarged starch-rich tuberous roots. The amount of carbohydrates contained in dry cassava root is higher than other staple crops, such as maize or cereals but, by contrast, the protein content is very low.

Although cassava is a staple it is poisonous in its raw state as the plant contains cyanogenic glucosides. These glucosides are converted to hydrogen cyanide (HCN) by an enzyme called linamarase, which is also present in cassava and acts on the glucosides when the plant cells are ruptured either when it is eaten or during processing.

The amount of cyanide present depends on the variety. There are two main types of cassava, bitter and sweet. While, in general, bitter varieties have higher levels of cyanide it must not be assumed that all sweet varieties have low cyanide levels. The cyanide levels range from 10 to 450 mg/kg of fresh root. The poison tends to be more concentrated in the skin of the root.

The cyanide is readily removed during processing, resulting in a safe and versatile product that can be made into many different foods and non-food products. After proper processing a final residue of hydrogen cyanide will remain at very low concentrations but it does not cause any problem regarding the consumption of cassava products.

Versatility of cassava

Traditionally cassava has been regarded as a subsistence crop for low-income families - providing high levels of carbohydrates during shortages of other crops because of its tolerance to drought and ability to grow in poor soils. Recently the view of cassava as simply a subsistence crop has begun to change and there is growing interest in developing its commercial potential through improved varieties, increased productivity, harvesting and processing technologies. Along with the increased production of cassava, new markets and uses for the crop are being developed.

Cassava roots are processed in many different ways to make it edible, to change its properties, remove cyanide and improve its storage capacity.

Cassava is made into flour, commonly known as *gari* in West Africa and *Farinha* in Latin America, which is an ingredient in many recipes and used to make cassava bread or to replace up to 10% wheat flour in conventional bread. In many cassava-producing countries there is interest in reducing the wheat flour importations. Brazil incorporates 2% of cassava flour in wheat flour bread and Nigeria has recently made it a requirement to have 10% cassava flour in its bread.

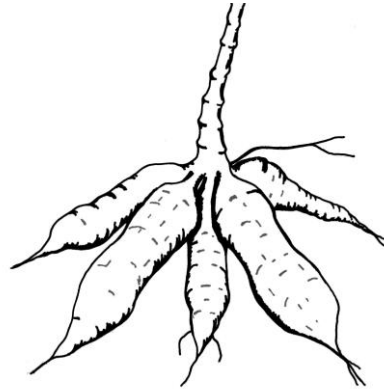


Figure 1: The cassava root
Illustration: Neil Noble/Practical Action

Cassava dough known as *fufu* in Ghana or *amala lafun* in Nigeria is made from cassava flour and plantain to produce rounded balls that can be eaten with fish, meat and soups. In Southern Africa cassava fritters are produced from grated or pulped fresh cassava combined with egg, onions, spices, breadcrumbs or cassava flour.

Similar products are produced in South America. In the Amazonian region cassava juice, with the starch removed, is boiled down and skimmed repeatedly until it ceases to froth, seasoned with pepper, garlic and other flavours and is used as a source for flavouring meat and fish. The product is known as *Tucupy* or *Casareep*. It can be boiled down further to make syrup. *Tucupy de sol* is made by putting the seasoned cassava juice in a lightly corked bottle and exposing it to the sun for several days. During the slow evaporation the cyanide is eliminated.

Other uses for cassava include animal feed made from the leaves and the dried root chips, and starch that is used as a food ingredient and in industrial processes.

Cultivation

Cassava can grow in poor conditions but yields increase when soil fertility is maintained and a good supply of water is used. Under very good conditions yields of fresh roots can reach 90 tonnes per hectare while yields from subsistence agricultural systems average 9.8 tonnes per hectare.

Traditionally, cassava is grown on small farms at a subsistence level. The application of fertiliser is usually limited among small-scale farmers due to the high cost and lack of availability. Soil depletion can be reduced by intercropping with crops such as vegetables, coconuts, yams, sweet potatoes, melons, maize, peanuts and other crops. In this respect legumes, which fix nitrogen are very important. Commercially produced fungicides and pesticides are not commonly used. Cassava is planted by hand, burying the lower half of the cutting, taken from the mature stem, upright in moist soil. The cuttings produce new roots and shoots within a few days but early growth is relatively slow. In the early stages of growth it is important to keep weeds under control. If fertilizer is being used it should be applied during the first few months of growth.

Organisations that have carried out research into developing cassava cultivation include The Natural Resources Institute (NRI), which aims to develop environmentally-friendly technologies to reduce crop losses from pests and diseases in developing countries, and the International Institute of Tropical Agriculture (IITA), that has developed improved varieties of cassava. Production has been increasing over recent years, partly in response to the new varieties introduced by IITA between 1988 and 1992 and because of government initiatives in the promotion of production and market development.

A number of new initiatives are currently being implemented to improve yields and expand the growing area to increase cassava production. For example the Cassava Growers Association in Nigeria has set out to purchase parcels of land suitable for commercial growing of cassava in a cluster farming system. This allows for improved farming methods including the use of high yielding plant varieties and shared use of mechanised equipment such as a hired tractor for ploughing.

The production of cassava is dependent on a supply of good quality disease-free and pest-free stem cuttings. The stem cuttings are sometimes referred to as 'stakes'. Dr. Robertson of the Faculty of Agriculture in the University of Zimbabwe has developed a low cost approach to propagating disease-free cuttings by growing the clean cuttings in cabinets before they are passed onto farmers. The yields from the disease free plants are very much higher than standard plants.

Harvesting

Plants are ready for harvest as soon as the tubers are large enough to meet consumer requirements. Roots can be harvested from 6 months up to 3 years after planting depending on the variety, enabling harvests to be delayed until market, processing, or other conditions are most favourable. However, as the roots age, the central portion becomes woody and inedible.

Most cassava is harvested by hand, lifting the lower part of the stem and pulling the

roots out of the ground, then removing them from the base of the plant by hand. The upper parts of the stems with the leaves are removed before harvesting the roots. Care must be taken during harvesting to minimise damage to the roots, as this greatly reduces shelf life. Mechanical harvesters have been developed that lift the roots from the ground. One such design comes from the National Centre for Agricultural Mechanization in Nigeria.

During the harvesting process, the cuttings for the next crop are selected. These must be kept in a protected environment to prevent them from drying out.

Cassava storage

Cassava can stay in the ground for a long time but once harvested can rot very quickly. Post harvest losses from rot, pests, rodents can be very high unless effective measures are taken.

Traditionally cassava has been stored by piling the roots into heaps that are kept watered to prevent the tubers drying out. Sometimes cassava is stored in pits that are lined with straw or other vegetable material and kept watered. Cassava can also be stored in containers with moist sawdust that keep the tubers from touching. Other approaches to storing for short periods are to keep the tubers under water or to coat the tubers in mud or ash to prevent moisture loss.

Modern storage methods have been adopted for commercial cassava production. One low-cost method developed by the Nigerian Stored Products Research Institute is to store the tubers in trenches. A layer of palm and raffia leaves is laid at the bottom of the trench and then a layer of roots is placed on top. A new layer of leaves is added, then more roots until the trench has been filled. The top of the trench is covered with earth and a roof is constructed above the trench.

Harvested roots are now frequently packed in plastic bags. The bags are airtight so limiting the supply of oxygen, which helps prevent the crop from rotting, although fungicides are sometimes applied before bagging the crop. The universal fungicide "Benomyl" restricts mould growth. The crop can be stored in this fashion for more than 14 days reducing losses during transportation. This has worked successfully in Columbia although it is not as well developed in African countries.

Another element to consider is temperature - the optimum storage temperature for fresh root is 3°C. Once cassava has been packed into plastic bags it can also be frozen and this approach is currently used in South America on a commercial basis. While the texture can be affected by freezing, the flavour is not.

Other preservation methods such as coating the roots with a wax containing fungicide, and dipping the cassava into cooled paraffin have been tried to a lesser extent.

Processing

Good quality raw materials are required for processing if the final product is to be of a good quality. Cassava should be free from disease, infestations and damage. The crop should be processed within two days of harvest to maintain product quality. Attention should be paid to the proper application of hygienic practices to prevent contamination. The cassava should be thoroughly washed, in potable water, to avoid contamination and waste material from the process should be removed to prevent cross-contamination.

Peeling

Ideally the cassava roots are peeled immediately after harvesting either with a traditional cutting tools such as a machete or with a mechanical peeling device. Typically one woman can peel

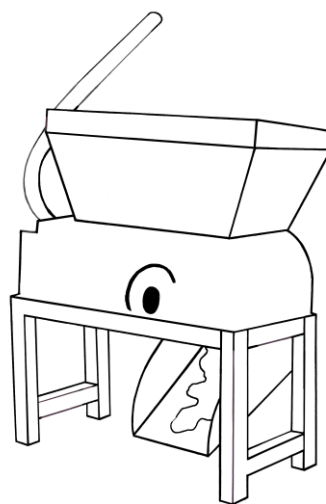


Figure 2: A cassava peeler
Illustration: Neil Noble/Practical Action

about 20 to 25 kg of roots in an hour. Around 30% of the fresh weight is lost during the manual peeling, when woody tips are also removed.

Various peeling machines that have been developed but they have not been universally accepted because the cost is too high for many small-scale producers and the machines result in too much wastage in the peeling process. The peeled roots then need to be washed to remove dirt and pieces of peel.

The peeled tubers are next chipped, grated, sliced, cubed or pelleted before further processing can take place.

Chipping

If the chips come from bitter cassava varieties, the roots are often kept in water for 2 to 4 days. This allows hydrogen cyanide to be released, reducing any public health hazard. The water must be carefully disposed of afterwards. Chipping can be done manually or with chipping equipment.

Grating and Rasping

Cassava is frequently grated or rasped as part of its processing. Traditionally it was a laborious activity carried out by hand. Now there is a large range of graters that can be used from the most basic manual and pedal operated graters through to fully motorised machines.



Figure 3: A cassava chipper
Illustration: Neil Noble/Practical Action

Drying

Cassava chips have to be dried to a moisture content of around 12 to 15%; from the original moisture content of 65 to 75%. Once dried the chips should break easily without crumbling.

If no other storage method is used drying should take place within 2 days of harvesting to ensure that the quality of the product is maintained.

Cassava chips are often infested by insects during the drying process so the time taken to dry the chips is important. The drying process can be shortened by increasing the surface area of the chips in relation to their volume - so the smaller the chips the faster the drying time. The larger chips therefore have to be reduced in size to improve their drying properties.

Traditionally cassava has been sun dried in the open air, either on the ground or on a raised platform. Solar drying techniques improve upon this traditional approach by protecting the product from the elements and by improving the airflow which reduces the time for drying.

Artificial drying can be used when the climate is not reliable enough or where the humidity is too high to use solar drying equipment. Artificial dryers are common as they are more predictable and controllable. Practical Action has developed various designs of tray dryer that can be used to dry fruit and vegetables and would be suitable for drying chopped cassava. Here economic factors must be considered as artificial dryers use fuel.

Making cassava flour

As flour, cassava can be stored up to a year if properly packaged. Traditionally cassava flour is made by pounding chips with a pestle and mortar. The process involves softening the tubers, cutting, drying and then pounding again or milling.

The moisture content is high so the roots need to be dewatered, which can remove up to 50% of the water. This can be done by various types of press. The more simple types consist of parallel press boards that can be screwed together. Hydraulic jack presses can also be used. The

The basic steps for making flour

- Sort
- Peel
- Wash
- Grate
- Dewater
- Pound or mill
- Dry
- Fine mill
- Sieve
- Pack

fermented paste is put into hessian or polypropylene sacks and placed in to the press. An alternative traditional approach is to use rocks to compress the sacks, which allows the fermentation and pressing to take place at the same time.

Sieving will produce a high quality product with similar sized granules. Larger particles that are separated during this process are sold as a cheaper grade.

The product should be packed into polythene bags to prevent any moisture being absorbed from the air. This is especially important in areas of high humidity. The bags should then be stored in a cool dry location.

Another approach to making cassava flour is to incorporate a fermentation stage which produces a slightly sour flavour product known as *Gari*. This can be done either during the dewatering stage or through retting which involves soaking the whole or cut roots in water for 3 to 5 days until root has fermented. The duration of fermentation should be carefully monitored to ensure that detoxification is complete but the product must also have an acceptable flavour and texture.

- The basic steps for making Gari
- Sort
 - Peel
 - Wash
 - Cut/grate
 - Pound or mill
 - Ferment
 - Dewater/dry
 - Sieve
 - Roast
 - Cool
 - Sieve
 - Pack
 - Store

Roasting the flour improves the storage capacity. It is done in a large, shallow pan over a fire, with constant stirring with wooden paddles for 20 to 30 minutes. It can be done with palm oil on its own. Cylindrical rotating roasters are used for in larger scale production setups.

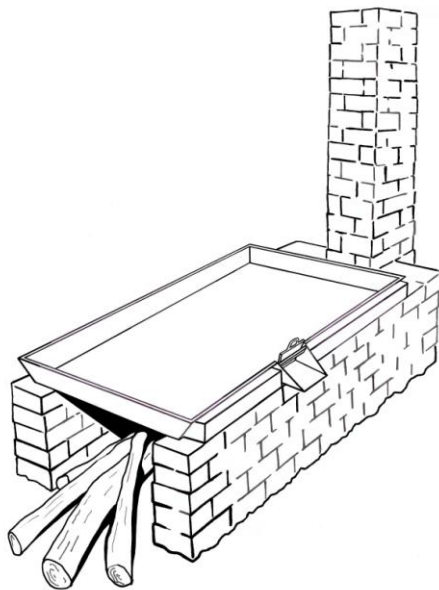


Figure 4: Cassava flour roaster
Illustration: Neil Noble/Practical Action

Fufu is made from cassava flour by pounding the material until a gelatinous sticky product results. Traditionally this was done using a pestle and mortar and could take up to an hour. Motorised pounding machines reduce the amount of work required. One such design was developed by the Department of Agricultural Engineering at the University of Ife in Nigeria.

Making starch

Starch is traditionally used for foods such as biscuits, bread, and as a base for puddings. It is also used for non-food applications such as in papermaking and in the textile industry.

There are two approaches to producing starch - non-fermented starch or soft starch, and fermented starch or sour starch. Constraints to cassava fermented starch production are the variable quality of the end product. Colour, expansion during cooking and water absorption are important qualities of starch.

- The basic steps for making starch
- Wash,
 - Chop or grate
 - Mill with water
 - Sieve
 - Mill again
 - Allow to settle
 - Separate - Drain the water
 - Remove the top layers of fine fibre
 - Ferment (optional)
 - Remove the starch, break and dry.

technical brief

Settling is used to separate the starch from the contaminants and fibre. The quality of the product is dependent on effective separation starch and water. Successive settling tanks or modern separators can be used. Each operation can be used alone or carried out in different combinations. The duration of settling process should be as short as possible as fermentation can start if left for too long. In modern processing methods the period between rasping and drying is kept to about one hour.

Traditionally, separation takes place in large vats that are difficult to handle and may involve significant starch loss. A more modern approach is to use channels which curve with a slight incline. Very high quality starch can be produced in these settling tables. Solar drying of starch is increasingly being replaced by artificial drying systems but it is reported that this can affect the swelling property of the starch.

Contamination of local water resources with high volumes of dilute liquid waste is a major consideration in the production of starch.

Animal Feed

Cassava is widely used as a feed for pigs, cattle, sheep, poultry and rabbits. Whole roots can be peeled, chopped and given to pigs. Dried root peel can be fed to sheep and goats.

Dried cassava roots contain a similar amount of energy to grains so can be used as a substitute for maize or barley but the roots lack protein so should not be used on their own. They should be supplemented with other feeds that are rich in protein and vitamins.

Raw or boiled roots can be mixed into a mash with protein rich materials such as maize, sorghum, groundnut, and oil palm kernel meal along with minerals to provide a balanced feed.

Cassava leaves can also be incorporated into feed. Although the leaves have a higher protein content than the roots it can only be used as part of the feed. If the amount is too high then the pigs will not fatten. The leaves need to be processed or left to wilt for a few hours to lower the cyanide level before feeding.

This commercial use of cassava as a feedstock has only become established in recent years but is increasing. In Europe the animal-feed industry uses dried cassava roots as an imported ingredient

Industrial uses

Research on the industrial use of starch is continuing to expand the market demand for cassava.

Paper

Starch from cassava, along with maize and potato, can be used in the production of paper. Different types of starch are used in various stages of paper production. An important new application of starch is in the coating of magazine paper.

Textiles

Starch is used in three main activities in the textile industry areas: sizing, finishing and printing. The majority, approximately 80%, of it is used in sizing, where individual fibres of yarn are formed into a warp that passes through a sizing solution to coat its surface. It is then heated and when dry the yarn is ready for weaving. Particular properties are required for the starch, which needs to be able to penetrate and bond with the fibres, resistant to abrasion and flexible.

Adhesives

Cassava, along with potato and maize, is a common source of starch for adhesive pastes. It is a popular base for adhesives, particularly those designed to bond paper in some form to itself or to other materials such as glass, mineral wool, and clay. Starch can also be used as a binder or adhesive for non-paper substances such as charcoal in charcoal briquettes, mineral wool in ceiling tiles and ceramics prior to firing.

The essential ingredients in starch-based adhesives are starch/flour, gelatinisation modifier sodium hydroxide (NaOH), viscosity enhancer/stabiliser (borax) and preservative (sodium formaldehyde). The amount of borax and NaOH must be determined experimentally so as to produce the correct viscosity and pasting temperature to meet the requirements.

Ethanol

The fermentation of converted starch can produce ethanol, a basic alcohol. The process is not new and has been used in food and pharmaceutical products over the years. Now there is renewed interest in ethanol as a bio-fuel as it can reduce overall CO₂ emissions. It has the potential to provide economic development to rural areas by improving fuel access, as well reducing dependency on imported fossil fuels.

Small-scale ethanol production plants have been developed which can produce approximately 4000 litres/day of alcohol at 96% depending on the model.

The plant will need good water supply and continuous electrical supply (around 50Kva). The plant will also produce around 2-3m³/hr of effluent. This has to be disposed of properly and is normally used as an animal feed.

Bio-degradable packaging

Kasetsart University (Bangkok, Thailand) has developed a bio-degradable cassava starch based packaging material that can be made into a variety of shaped products. These can be used in place of fossil fuel based plastics products. The material is low cost, easily processed, biodegradable and can be made from agricultural surplus raw materials.

Quality control

For commercial enterprises quality and consistency of the product becomes important, especially when considering export markets. Careful monitoring of the composition of the raw material and the properties of the finished products is required. Quality control should be incorporated in to the production process. The two most important ingredients in processing are the cassava roots and the water used.

A simple method of ensuring a consistent standard of quality is to undertake small-scale processing trials to compare the product with standard samples. When cassava is used as food it is important to test for the presence of hydrocyanic acid. Analysis of commercial starches is becoming more important in the commercial setting. Standards and methods of analysis for starch and its products have been issued by the International Organization for Standardization.

Further reading

- *Cassava in Tropical Africa: A Reference Manual* [International Institute of Tropical Agriculture](#) / UNICEF, 1990, ISBN 978 131 0413
- *Making Manioc Starch in Sri Lanka: A Rural Industrial Enterprise* By Reverend John Kennedy, Eastern Technical institute, Batticaloa, Sri Lanka [Appropriate Technology Vol. 6](#) No 3 November 1979
- [Artisanal Production of maltose from cassava starch](#) Food Chain Number 21 July 1997
- *A Semi-automatic Device for Planting Cassava Stem Cutting on Ridges;* Vol. 2/4 [Appropriate Technology](#), February 1976
- [Cassava – Variations on a Theme](#) Food Chain Number 17 March 1996
- *Village-Level Cassava Processing: Distance learning package (10 Field guides and 1 tutor's manual)* Z. Bainbridge and K. CNT US Wellings NRI, 1997, ISBN: 0859544567
- *Traditional Storage of Yams and Cassava and its Improvement* GTZ
- [Adding Value to Cereals, Roots and Tubers](#) Domien Bruinsma, CTA, 1999, ISBN 92 9081 2928
- [Cassava Processing: Plant Production and Protection Series No 3](#) by M.R. Grace, FAO

In the early 70s, an engineer at the ITDG (now Practical Action) workshop in Zaria, Nigeria developed a cassava grater made from steel tubing, spare bicycle parts, hacksaw blades and sheet metal. Cassava is fed in the hopper and a vertical disc with grating slits fixed to a frame is rotated by pedal power. Details available from Practical Action.

Links

- [Championing the Cause of Cassava -FAO](#)
- [IITA – Cassava](#)
- Visual Training manual – Gari Production from Cassava
IMDP Project Manager
Rose Clarkson
John Muir Building, Kings Buildings,
University of Edinburgh,
Mayfield Road, Edinburgh EH9 3JK
Scotland, UK
Fax: + 44(131) 650 7214
Email: enquiries@imdp.org.uk

Organisations

International Institute of Tropical Agriculture - IITA
c/o Lambourn (UK) Limited,
Carolyn House 26 Dingwall Rd., Croydon, CR9 3EE, United Kingdom
Tel: (44) 020 8686 9031
Fax: (44) 020 8681 8583
E-mail: IITA@cgiar.org
Website: www.iita.org/

ICP – Nigeria
International Institute of Tropical Agriculture
Ibadan office: PMB 5320 Oyo road Ibadan, Oyo State
Onne office: PMB 008, Nchia, Eleme, Port Harcourt, Rivers State, Nigeria
Tel: (234 2) 241 2626 Ext 2328
Fax: (234 2) 241 2221
Email: iita-icp@cgiar.org

The Integrated cassava project website <http://www.cassavabiz.org/>

IITA's mission is to enhance the food security, income, and well-being of resource-poor people in sub-Saharan Africa through research and related activities to increase agricultural production. Research focuses on smallholder cropping and postharvest systems and on the following food crops: cassava, cowpea, maize, plantain and banana, soybean, and yam.

Natural Resources Institute - NRI
University of Greenwich
Central Avenue
Chatham Maritime
Kent, ME4 4TB, United Kingdom
Website: <http://www.nri.org/cassava-smes/>
CASSAVA-SMEs is a project with the overall aim to develop selected cassava based foods through the manufacture of high quality products.

Technology Consultancy Centre - TCC
University of Science and Technology
Kumasi
Ghana
Tel: +233 51 60297
Fax: +233 51 60137
Institute of Industrial Research

P. O. Box LG 476

Legon, Accra

Ghana

Tel/Fax: (233)-21-500193

E-mail: ebenhagan@kiteonline.net

Develop technologies such as dyeing technologies, cassava harvesting and processing equipment for starch production, including an integrated cassava processing plant.

GRATIS (Ghana Regional Appropriate Technology Industrial Service)

P.O. Box 15, Tema, Ghana

Tel: +233 (0) 22 14243

Fax: +233 (0) 22 16251

E-mail: gratis@ighmail.com

Website: <http://www.gratisghana.com>

GRATIS manage a network of Intermediate Technology Transfer Units (ITTU's) promoting appropriate technology around Ghana. Products developed include a cassava grater.

Agricultural Engineering Department

College of Engineering

KNUST – Kwame Nkrumah University Science and Technology

Kumasi

Ghana

Tel: +233 (0)51 60317

Fax: +233 (0)51 60317

E-mail: agriculturalengineering@knust.edu.gh

Website: <http://www.knust.edu.gh/>

CIAT Cassava Program

Apartado Aereo 6713

Cali

Colombia

Tel (57)-2-4450-000

Fax (57)-2-4450-273 USA

Fax (305) 592-4869

E-mail ciat-cassava@cgnet.com

EMBRAPA, Centro Nacional De Pesquisa De Mandioca E. Fruticultura, Rua Embrapa s/n, Caixa Postal 007, Crus Das Almas, Bahia, Brazil, CEP: 44380-000

Tel: 55 (075) 721-2120

Fax: 55 (075) 721-1118

E-mail cnpmf@brfapesp.bitnet

E-mail: postmaster@cnpmft.embrapa.anba.br

Equipment and suppliers

Note: This is a selective list of suppliers and does not imply endorsement by Practical Action.

Foodnet - Post-harvest equipment listing

Equipment covering; transportation, harvesting, peeling, fermentation and dewatering, grating and chipping, starch production, drying, storage and gari frying.

http://www.foodnet.cgiar.org/agro_ent/process/Process.htm

Department of Agricultural Engineering

Faculty of Engineering

University of Nigeria

Nsukka

Nigeria

- Gari Frying Machine

The machine consists of a long trying trough and 16 spring loaded paddles. The paddles move in one direction and press the mass against the hot surface of the trough.

Throughput: 66Kg gari/hr

technical brief

Agricultural Engineers Limited
 Ring Road West Industrial Area
 PO Box 12127
 Accra North
 Ghana

- Gari Roaster
 This is designed to roast pulverized and sieved cassava dough. The roasting pan has been constructed with a 3mm iron plate and a chimney is provided to make the roasting process smoke free.

Visayas State College of Agriculture
 8 Lourdes St.
 Pasat City
 Philippines

- Root Crop Cuber
 Pedal operated, for preparing root crop cubes with a capacity of up to 150kg/hr.

Department of Agriculture, Forestry and the Environment
 P. O. Box 18
 Magburaka
 Tonkolili District
 Sierra Leone

- Gari Processing Machine / Fruit and Vegetable Choppers
 This machine is used for processing gari (roasted cassava) on a small scale.
 Food Groups: Root crops/tubers
 Capacity: 50 kg/hour

Alvan Blanch
 Chelworth
 Malmesbury
 SN16 9SG
 United Kingdom
 Tel: +44 (0)1666 577333
 Fax: +44 (0)1666 577339
 E-mail: info@alvanblanch.co.uk
 Website: <http://www.alvanblanch.co.uk>
 Food processing equipment suppliers

- Batch Driers / Drum Driers
 An efficient and economical method for processing a wide variety of crops. Used for the drying of grains, pulses and non-granular materials such as alfalfa, herbs and root crops – cassava and yams.

Rohrex Ltd
 283 High Street
 Aldeburgh, Suffolk IP15 5DG
 United Kingdom
 Tel: +44 (0) 1728 452174
 Fax: +44 (0) 1728 452174
 Email: projects@rohrex.com
 Website: www.rohrex.com

- A range of mini processing plants, equipment and project services to the agro - industrial sector. There is increasing demand from lesser-developed countries for cost-effective medium technology equipment and processing options located close to natural resources. This is particularly relevant to perishable produce such as cassava, potatoes, and fruit.

Dairy Udyog

C-230, Ghatkopar Industrial Estate
 L.B.S. Marg
 Ghatkopar (West)
 Mumbai - 400 086
 India
 Tel: +91 22 517 1636 / 517 1960
 Fax: +91 22 517 0878
 Email: jipun@vsnl.com

- Batch Driers / Drum Driers - Used for drying of grains, pulses and non granular materials such as alfafa, herbs and root crops such as cassava, yams, chillies etc.

Rajan Universal Exports (mfrs) Ltd.
 P. O. Box 250
 Madras, 600 001
 India
 Website: <http://www.rajeximp.com/rajeximp/index.html>

- Cassava Grater - The Grating blades rotate at high speed. 1.5, 2.25 and 3kW versions are available 200 Kg to 1000 Kg/hr.

Agricultural Engineers Ltd.
 Ring Road Industrial Area
 P. O. Box 12127
 Accra North
 Ghana

- Wadhwa Cassava Grater - Manually operated by crank handle, the free-standing machine has a rotating abrasive drum 124 to 180 kg/hour.
- Wadhwa Cassava Peeler - Requires a 5.5kW electric motor or diesel engine.
- Produce a disc grating machine driven by a 3.75 kW engine.

Outils Pour Les Communautés
 P. O. Box 5946
 Douala
 Cameroon
 Tel: 237 370432
 Fax: 237 370402

- Grinders

Department of Agricultural Engineering
 Faculty of Engineering
 University of Nigeria
 Nsukka
 Nigeria

- Manually powered crank driven grater.

Unata C.V
 P.O.Box 50
 Nieuwlandlaan B-437
 3200 Aarschot
 Belgium

- Produce a lever-action manually powered cassava grater.

Gauthier
 Parc Scientifique Agropolis
 34397 Montpellier
 Cedex 5
 France
 Tel: +33 (0)4 67 61 11 56
 Fax: +33 (0)4 67 54 73 90

- Produce a cassava grater with a throughput of 1 to 3 tonnes/hour.

technical brief

Uganda Small-scale Industries Association
P.O. Box 7725
Kampala
Uganda

- Grater/Chipper with a throughput of 200kg/hour

Agriculture & Food Processing Machinery Consultative Center - AFPM CC
NO.6 Beichang Street, Anyang, Henan
China, 455000
Tel: +86 372 5153917
Fax: +86 372 5914505
E-mail: yunyi6088@163.com, afpmcc@yahoo.com.cn
Website: <http://www.afpm.cn>

- Cassava starch processing machinery comprising of; washer, rasper, vacuum filter, centrifugal sieve, starch hydrocyclone, airflow dryer, starch sifter, blade centrifuge, hammer crusher, automatic packer and elevator.

Practical Action
The Schumacher Centre
Bourton-on-Dunsmore
Rugby, Warwickshire, CV23 9QZ
United Kingdom
Tel: +44 (0)1926 634400
Fax: +44 (0)1926 634401
E-mail: inforserv@practicalaction.org.uk
Website: <http://practicalaction.org/practicalanswers/>

Practical Action is a development charity with a difference. We know the simplest ideas can have the most profound, life-changing effect on poor people across the world. For over 40 years, we have been working closely with some of the world's poorest people - using simple technology to fight poverty and transform their lives for the better. We currently work in 15 countries in Africa, South Asia and Latin America.

technical brief