STUDIES ON ROOT AND TUBER CROPS PROCESSING AND PRESERVATION AT THE VILLAGE LEVEL IN GHANA

DRAFT FINAL REPORT

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SMALLHOLDER REHABILITATION AND DEVELOPMENT
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1. SUMMARY OF RECOMMENDATIONS

General

1.01 Adequate funds should be allocated to rehabilitate, upgrade and develop the root and tuber processing and preservation subsector of the agricultural sector of the economy.

1.02 A compendium of cassava processing units in the country should be compiled by extension and post-harvest development officers of MOFA in collaboration with staff of District Assemblies.

1.03 Improved cassava storage techniques should be encouraged and promoted in rural areas where the crop is grown and processed.

1.04 Boreholes for potable water should be provided in suitable locations in villages for use by cassava processors.

1.05 Barring initial high cost, the use of diesel engine for operating cassava processing machines should be encouraged.

Gari production technology

1.06 The design and development of a cassava peeler should be encouraged and promoted.

1.07 Improved methods of washing peeled cassava in suitable containers should be encouraged.

1.08 The use of power-operated cassava graters for processing cassava in villages should be promoted.

1.09 The use of dewatering/fermentation press should be encouraged and promoted.

1.10 The use of standardized starter cultures in cassava fermentation at the village level should be encouraged and promoted.

1.11 An aluminium sieve with the same aperture size should be gradually introduced alongside the present cane sieve.

1.12 The use of improved gari roasting stoves which use LPG or biogas, should be introduced and promoted in village cassava processing areas.

1.13 Better packaging of gari for storage or retailing should be promoted.

Agbelima production technology

1.14 Studies should be conducted into agbelima production with regard to fermentation, storage, sale and the maintenance of sanitation and hygiene at production sites.

Kokonte production technology

1.15 A study should be conducted into infestation and damage caused to kokonte in storage so as to map out a strategy of suitable control.

1.16 An improved crib for the drying and storage of kokonte should be introduced and promoted.

Capacity utilization

1.17 There is the need to increase the level of capacity utilization of NGO-funded cassava processing plants through proper siting and effective supervision of operations.

Mobile cassava processing

1.18 In order to generate more income and also assist in village-level processing and subsequent rural industrialization District Assemblies and/or individuals should establish and operate mobile cassava processing units.

1.19 Drying units for producing cassava chips for export should be set up on co-operative basis in selected high potential cassava growing villages.

Starch industry

1.20 In order to reduce or eliminate starch imports, create employment opportunities, catalyse increase cassava production and service starch-using establishments, there is the need to establish a cassava starch manufacturing industry.

Tapioca and fufu flours

1.21 The production of tapioca and fufu flours from root and tuber crops should be promoted.

By-products utilization

1.22 Apart from their use as animal feed, the use of cassava peels in mushroom production needs to be investigated and promoted.

Human resource development

1.23 Training in cassava processing and preservation for village level cassava products' manufacturers with a view to improving upon their operations and the quality of their products should be initiated and promoted.

Yam processing and preservation

Curing and storage

1.24 Yams meant for storage after harvesting should be cured before storage so that the skins can be toughened and wounds inflicted on the tubers during harvesting and subsequent transportation and handling can be healed.

1.25 Yams storage structures should provide adequate shade, good ventilation, security against pest and predators and good sanitation before storage. Wound-free, rot-free and sprout-free yams should selected for storage and there should be regular inspection and continued sanitation during storage.

1.26 The improved crib used for maize storage should be modified for yam storage.

Transportation of yam

1.27 To prevent damage to yams during transportation layers of yams should be separated from each other with dry grass or any cushioning materials.

Yam processing factory

1.28 A yam processing factory should be established in Northern Ghana.

Wasawasa production

1.29 The technique used in the production of wasawasa from yam pieces and peels should be improved and standardized so that it can be produced and marketed in a more hygienic and acceptable way.

Processing plant establishment

1.30 Cassava processing plants, especially for gari, should be set up in the Damongo and adjoining districts in areas of very high cassava production.

Root and tuber crops development board

1.31 The Government of Ghana should establish a Root and Tuber Development Board to, inter alia, promote increased production, processing and preservation of root and tuber crops.

Cocoyam, sweet potato, frafra potato processing and preservation

1.32 Research and development studies into the production, processing, preservation and utilization of cocoyam, sweet potato, and frafra potatoes should be encouraged and promoted since very little is being done for these crops at the moment.

Locally-produced equipment

1.33 There exists good indigenous technology for the design and manufacture of root and tuber crops processing and preservation equipment.

However, improvements are needed in specific areas.

Workshop

1.34 There is lack of well-organized plant layout in most workshops. With the need to produce higher number of processing units of better quality serious efforts should be made to improve upon plant layout so as to improve plant operation efficiency.

Design

1.35 Modifications are needed in the leverage press by a loaded spring backed weight in the cylindrical graters and the replacement of the perforated metal sheet with a milled surface grating unit.

For the cassava press, modification should address the reduction in human effort and the collection of the liquid exudate for further processing.

For the roasters, improved designs should aim at addressing the reduction in drudgery, discomfort, energy consumption per unit of output and the use of LPG to reduce excessive reliance on woodfuel.

Spare parts production

1.36 Manufacturers of root and tuber crops processing equipment should be requested to produce spare parts for their equipment and these should be available at designated shops for purchase.

Drawings

1.37 Manufacturers of root crops processing equipment should, on their own, produce drawings of the machines they produce or be assisted by local institutions to do this for future duplication and/or standardization so as to facilitate commercialization and production of spare parts.

Standardization

1.38 There is generally no standardization in the use of materials and tools in the production of root crop processing machinery.

There is also no standardization in the equipment itself. Minimum standards need to be formulated by the Ghana Standards Board for both construction materials and equipment.

Human Resource Development in Equipment Manufacture

1.39 Technical and managerial skills are lacking among manufacturers of root crops processing machinery. Local technical institutions need to mount intensive training courses at affordable cost for these small scale entrepreneurs.

Capital

1.40 Lack of capital is a major constraint for these operators. To solve this problem, a clearly-defined policy on micro and small enterprises need to be formulated for financing the whole sector of Small and Micro Enterprises.

Construction materials

1.41 Manufacturers of root crops processing equipment depend on scrap as raw construction material, which is not good enough for food where hygiene and avoidance of contamination are important. In the short-term such a situation is unavoidable but in the long-term production of iron and steel should be undertaken.

Improved cassava varieties release

1.42 Three improved varieties have been released together with their names. These are:

1. Abasa fitaa which is an all-purpose cassava and therefore can be used for fufu, ampesi, gari, agbelima and kokonte.

2. Gblemo Duade which can be used only for gari, agbelima and kokonte.

3. Afisiafi which can be used for gari, agbelima and kokonte.

1.43 The MOFA through its Crops and Extensions Services Departments should see to the promotion of the production of these varieties so that they would be available for use in processing into various food forms.

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II. BACKGROUND

Country Profile

2.01 Ghana is an independent tropical republican country in West Africa located approximately 5 degrees above the equator and 5 degrees below the sub-sahara belt, and occupying land mass of 238,540 sq.km. The country is sub-divided into 10 regions namely Greater Accra, Central, Western, Eastern, Ashanti, BrongAhafo, Volta, Northern, Upper East and Upper West. The total population of the country in 1990 was estimated to be 14.9 million. The capital city is Accra with over 1.0 million inhabitants.

Economy

2.02 Ghana is endowed with rich mineral resources, the main traditional resources being gold, bauxite, diamond and manganese.

In addition to the rich mineral resources, Ghana has abundant resources in forestry and agricultural products supported by good climate and fertile lands. Of about 57% agricultural land area, 18% was under cultivation and 0.03% was under irrigation in 1990.

2.03 Agriculture is the largest sector of the economy contributing about 50% to the Gross Domestic Product (GDP) in 1991 and accounting also for about 60% of export earnings. Eighty five per cent of all farming is done by small scale farmers using traditional technology. The greatest production emanates from root and tuber crops made up of cassava, yam and cocoyam. These contribute about 46% of Agricultural (GDP) with yams exhibiting the largest growth rate in area planted and coming third after groundnut, maize and cowpeas in production growth rate. Plantains account for 9% of Agricultural GDP.

Cocoa is the second largest subsector contributing about 13% of Agricultural GDP. The third largest sub-sector is forestry with a contribution of 11% of Agricultural GDP, and cereals - maize, rice, sorghum, millet contributing 7%.

2.04 In contrast with agriculture, the manufacturing industries in Ghana are dominated by modern enterprises which are highly dependent on imported inputs and equipment. The manufacturing industries have made significant contribution to the economy of Ghana since the country adopted an important substitution industrilization strategy soon after her independence in 1957. This led to the establishment of a number of industries which supply goods which were hitherto imported, particularly in the production of tabacco, beverages, aluminium ware, paints, household enamel ware, flour, asbestos cement pipe, aluminium sheets etc.

2.05 The agro-based industries form the largest sub-sector to the manufacturing industries both in terms of numbers of enterprises operating and in the varieties and quantities of goods produced. Two main groups constitute the agro-industries, the food group and the non-food group. The food group consists of the traditional or indigenous industries whose main characteristic is the production of staple foods to meet the consumer needs of the various socio-economic units of the Ghanaian population. These traditional food processing industries which are small scale and are scattered all over the country, are divided into root and tubers, cereals oilseeds, fish and beverages processing enterprises. Of the traditional food processing industries the most widespread in the rural areas are the root and tuber crops especially cassava.

The non-food group are few and large scale and are located mostly in urban centres.

2.06 By 1977 there was a decreased economic performance in the country resulting in wide scale deterioration in most manufacturing enterprises and this drastically affected the food processing sector until the commencement of the government's Economic Recovery Programme (ERP) in 1983. A major feature of the ERP has been the launching of rehabilitation programmes in key sectors of the economy and this includes the development of the food processing sector through priorities established for the agricultural sector. In relation to the sector, the specific aims and objectives are to achieve self-sufficiency in food crops through efficient production of cereals, starchy staples and animal protein food with priority given to cassava and maize. In addition to production, a priority area identified is the reduction in post-harvest losses through efficient storage for small scale farmers, increased efficiency in the processing of agricultural produce by the agro-business sector etc. Due to the emphasis on increased agricultural output, the changing export processed foods, the need to improve and develop existing food processing activities or introduce new food processing technology has been given much importance. Processing not only serves as a means of preserving and conserving agricultural produce but also adds value to the raw agricultural commodity that is produced locally.

2.07 In spite of the high Agricultural GDP and the provision of the bulk of Ghana's basic staple food requirements, root and tuber crops receive insignificant proportion of the limited research funds available for agricultural research. Maize which contributes 4% of Agricultural GDP received 11 person-years of research efforts while cassava, yam and cocoyam which contribute 46% received less than 7% person years of research efforts in 1988 according to the Medium Term Agricultural Development Programme (MTADP) launched in 1991.

2.08 While conceding the importance of root and tuber crops in Ghana's food security the nature of these crops present a number of problems. They are highly perishable and bulky containing 53-65% water per 100 gram of edible portion and have low levels of proteins, etc. Adequate processing and preservation can adquately address these problems. There is therefore the need to rehabilitate and develop the root and tuber crops processing and preservation subsector both by upgrading traditional technologies in the country and by introducing new and effective technologies through technology transfer possibly from other countries. This therefore necessitates the identification, evaluation and documentation of the available root and tuber crops processing and preservation technologies with a view to identifying existing equipment, weaknesses in the technology, if any, and the areas in which upgrading and transfer of technology are necessary at the village level where the bulk of processing and preservation activities are done.

2.09 In the search for ways and means of improving village level technologies in root and tuber crops processing and preservation in Ghana, the Smallholder Rehabilitation and Development Programme (SRDP) a Ghana/IFAD project therefore commissioned a short-term consultancy into the studies of root and tuber crops processing and preservation in October, 1991 for a duration of twelve (12) months under the SDRP Project No.GHA/86/F01 IFAD LOANS 198 GH/SRS - 002 GH.

A. Basic Project Studies

2.10 The basic project studies were twofold:

- survey of root and tuber crops processing and preservation methods and equipment at the village;

- survey and evaluation of small scale equipment produced in Ghana for root and tuber crops processing and preservation;

B. Objectives

2.11 The objectives of the studies were threefold:

- to identify constraints in the processing and preservation of root and tuber crops at the village level;

- to recommend already viable small scale processiong equipment and preservation methods to the farming communities involved in processing and preservation and where necessary to recommend improvements or modifications to the equipment and methods in use;

- to assess the suitability of improved cassava varieties to the local processing methods.

C. Studies methodology

2.12 To achieve the objectives of the studies the following methodology was used:

- a review was made of some country reports and related documents and of journal literature relevant to the studies;

- three different questionnaires shown in Annex 1 on processing, preservation and locally-produced small scale equipment were prepared and were used to collect information in a country-wide survey;
- visits were made to root and tuber crops processing and preservation centres and machinery manufacturing and distributing establishments in many villages, towns and cities in the ten regions of Ghana to observe their methods and scales of operation, manufacturing capabilities etc. and to assess their needs;
- visits were made to research and academic institutions and government departments which are actively involved in root and tuber crops processing and preservation and in the fabrication of processing equipment in Ghana;
- the data collected in (i) to (iv) have been analysed in the preparation of this report.

D. Final Report

2.13 This report consists of three main headings which includes the Background as the first heading or chapter. The second chapter is the Findings and Conclusions which gives a diagnostic status of the processing and preservation of root and tuber crops at the village-level in Ghana and evaluates specific technologies. The third chapter, Recommendations, makes recommendations (some through appendices) from the findings and conclusions with a view to assisting in the improvement of the processing and preservation of root and tubers crops overall particularly at the village-level.

A Summary of Recommendations is provided at the beginning of the report. A list of reference of information used in the study in addition to specific technical data etc. are provided in numerous Appendices in this report.

III. FINDINGS AND CONCLUSIONS

A. Cassava Processing and Preservation

Registration

3.01 All the cassava processing units surveyed are small scale and are in the informal sector of the economy. They are not registered as commercial enterprises and therefore have no legal statutory existence. Only a few especially the NGO funded units have signpots bearing their names and location.

Ownership

3.02 Except for the few that have been funded by NGOs which are run by local institutions, most of the processing units are individually - and/or privately-owned and are operated by semi-skilled or skilled hired labour.

Custom milling

3.03 The individually-owned processing unit, which consists of either a single cassava grater or a cassava grater and plate attrition mill (corn mill) run in most cases by a diesel engine operates as a customer service enterprise where cassava roots are grated for a fee. The institution owned units operate both as a customer service centre and as a processing plant producing cassava dough (agbelima) and gari since they possess presses and roasting units in addition to graters and plate mills found in individually-owned units.

Cassava Varieties Processed/Preserved

3.04 There are various varieties of cassava which are processed and/or preserved by processors or farmers. Most of them have local names which differ from region to region and at times from locality to locality. However, the 6 month and/or 12 month maturing varieties predominate.

Roots Availability and Cost

3.05 Mature cassava roots are relatively available throughout the year mostly from individual farms. During the dry season, however the fresh cassava roots are scarce and more costly due to the difficulty experienced by farmers in uprooting the crop. During the harvesting season, the price of the roots are reasonable. On the whole the price of raw cassava roots averages thirteen cedis per kilogram throughout the year.

Fresh Roots Storage

3.06 Fresh cassava roots begin to deteriorate within 48 hours after harvesting, initially due to enzymatic action in the roots and then to rot and decay. No post-harvest storage of the fresh cassava is therefore practised before processing by processing unit. The roots are either uprooted, peeled and dried in the sun or are uprooted, peeled and washed and then sent to custom service mills for grating and subsequent processing into gari and agbelima. For continuous operation and increase in capacity utilization of processing plants cassava roots need to be readily available for at least 5

working days. This can be achieved if suitable storage of the roots can be undertaken.

Water Availability

3.07 Although availability of potable water is a vital requirement for the establishment of a cassava processing plant (as it is needed for washing peeled roots, processing equipment and floors) most of the processing units have neither water nor facility for providing potable water for their operation. One reason is due to the fact that because they operate as customer service units they find such provision unnecessary as they expect customers to bring only peeled and washed cassava roots to their premises for grating. Another reason is the work entailed in trekking to obtain large amounts of water as headloads from local rivers and streams. A few NGO processing units however have boreholes to enable them operate fully as a cassava processing plants, while other plants have to purchase water from mobile water contractors to enable them operate.

Source of Power

3.08 Except for processing units which are in semi-urban areas which use electric motors, the source of power for a village cassava processing unit is 6kw (8hp) diesel engine because electric power supply in most cases is not available. Cassava processing units which use electric motor as the prime motive power at times have problems with starter switches. This may be due to faulty assembly, intermittent power outage, worn out contact points, moisture arising out of processing operations and high humidity within some of the buildings in which the machines are housed.
The cost of the diesel engine may be as high as 3 to 5 times the cost of an electric motor of the same rating. However, the diesel engine does not depend on external source to

generate power. When properly installed and serviced, the diesel engine is more likely to give trouble-free service for a very long time.

Labour

3.09 In the predominantly custom service processing system, only one operator with or without an assistnat who man the operations of the unit. In the NGO institution-owned processing units where gari is also produced, the labour required vary from 3 to 10 adults, one or two of whom are men. For such units, there is always a group or groups of women with a leader or leaders who work on scheduled days in the plant. Apart from the locally-resident group(s) of women, in some cases there is an overall supervisor of the unit who may be a regional or a district organizer of the processing plant, and who usually is not locally-resident and therefore,exercises virtually little or no supervision of the daily operations of the plant.

Processing Technology

3.10 The procesing technologies in use are indigenous and have several objectives which are meant to

1) detoxify cyanide and transform highly perishable crop into a product of longer storage life as in gari production;

2) transform a highly perishable crop into a more convenient and easily marketable form as in gari, agbelima (cassava dough) and fermented cassava chips (kokonte) production;

3) meet consumer demand for a staple food as in gari and agbelima production;

4) meet local and export market demands as in gari and agbelima production.

In the processing technologies, the cassava undergoes various operations in efforts by mostly women to process the roots into different products. These operations are shown in the flow charts in Annex 2. The operations include basically, peeling, washing, cutting, grating and depending on the end-product envisaged, the opérations would include fermenting, dewatering, sifting, roasting, sieving, drying, packaging and storage. The most sophisticated traditional processing operations and product of the cassava is gari.

Gari production technology (vide Annex. 2.....)

Peeling

3.11 This involves the removal of the cassava peel with a knife, the cassava being held in one hand and the knife held in the other. The operation is slow and time-consuming since the rate of peeling depends on the type and size of the cassava root. The rate varies widely and averages 25-50kg of peeled cassava per person hour with a peeling loss of about 20-30 per cent of the edible portion of the cassava. There is the danger of the human peelers injuring their fingers with the peeling knife in the peeling process.

Washing

3.12 This involves the cleaning of the peeled roots in water contained in enamel or aluminium bowls or plastic or galvanised buckets using sponge at times. Processors and/or their dependants usually have to walk long distances to fetch water to enable them wash peeled cassava. Due to the frequent scarcity of water, peeled cassava wash water is used several times without replenishing. The roots however emerge from the washing operation clean because of individual attention usually given to each tuber, the wash water on the

other hand becoming frequently loaded with dirty sediments from the roots.

Grating

3.13 Grating or milling of the cassava roots is achieved either manually or mechanically. In the manual process the cassava is grated by means of a hand held grater which is a curved nail-perforated galvanized sheet metal nailed to a wooden board which is held either inclined on the inside edge of an enamel bowl receptable with the lower end sitting inside the bowl or held against the thigh with the lower end in the receptacle. The peeled and washed cassava root is rubbed manually and continuously against the sharp ridges of the perforations which constitute the grating surface and by this cassava mash is produced which collects in the receptacle. Grating with this equipment is labourious and time-consuming and of very low output. By this method only 18-23kg of cassava may be grated in an hour. Because of danger to the fingers it is not possible for a processor to grate a whole cassava completely and therefore about 3-5 per cent of the root is usually left ungrated. The hand held grater is usually not properly cleaned and cassava chippings left lodged in the perforations at times become foci for microbial growth and subsequent food contamination. It is however very inexpensive and very easy to construct.

3.14 Many vilage communities now have mechanical cassava graters run mostly by 6kw (8hp) diesel engines and a very few by 7.5-11.2 kw (10-15hp) electric motors which provide customer grating service not only for resident village cassava processors but also for other communities within 1.2 to 2.4 km radius. There are two main types in use; cylindrical/ drum and disc types. Compared to the hand held grater, the output of mechanical graters is very high averaging 500-1000kg of grated cassava per hour.

Fermentation

3.15 The fermentation operation in most cases, is combined with the dewatering operation in which the grated cassava mash is loaded into jute or polypropylene sacks or baskets covered with sacks and heavy stones are piled on the pulp. During this process which takes 2 to 4 days and at times longer to complete in the production of gari, about 30% of the juice, is pressed out of the mass and at the same time a degree of fermentation takes place which causes cyanide detoxification and the development of a sour taste. The unstandardized nature in the fermentation operation which relies on natural microflora contact results in considerable variation in the final product of the entire process; from acidity to undesirable flavour. The operation is also time-consuming and the liquor from the mash is usually allowed to freely drain onto the ground, thereby not only wasting the liquor from which starch can be obstained but also making the working areas soggy and creating very unhygienic conditions which attract a lot of flies leading to environmental hazard. The end of the fermentation is usually indicated by the appearance of some froth on the outside of jute bag. The fermented mash may have a moisture content of about 45 per cent.

Dewatering

3.16 Dewatering, as earlier indicated, is achieved by placing heavy stones on sack or baskets loaded with the cassava mash. There is however, a gradual introduction of parallel board and other screw presses for improving the whole fermentation/dewatering operation overall, in some processing

units especially in the NGO-funded units. Due to the financial cost involved in their acquisition coupled with their low patronage even as custom service gadgets and their limited capacity, the use of the presses is very limited and not widespread especially in individually, privately-owned cassava processing units.

Sifting

3.17 The fermented, dewatered cassava mash is manually disintegrated and sifted through traditional cane sieve on the application of moderate hand pressure in a rotary motion. The aperature size of the sieve has been found to correspond to 400 microns (0.157mm) or 3.99 x 10^{-3} m which is ASTM (American Society for Testing Materials) Mesh No.5. The primary aim of the sifting operation is to remove or sort out woody portions of the fermented, dewatered mash to obtain a fairly uniform product. The operation also aids the subsequent roasting operation in that the particle sizes of the product being relatively uniform could be heat-treated at the same temperature in the same time period. A saving in energy consumption in the roasting operation is therefore achieved since otherwise additional woodfuel may be needed to roast oversized and unwanted materials which may result in the charring of undersized ones and the lowering of the aesthetic and market value of the resultant end-product, gari.

3.17 Roasting

The fermented, dewatered and sifted cassava mash is roasted in either a shallow slightly concave cast-iron pan or in a shallow slightly concave earthernware vessel mounted either on a three-legged clay mound stove or on a dug-out hearth both of which employs wood fuel fire as the energy source. The stove exists in may forms, stones, bricks, rubber tyre rims, etc. three of each group placed in a triangular shape

is used. The most common form is the three clay mounds which is constructed on the ground with gaps left in between the mounds to act as woodfuel stoke holes. Resultant flames from lighted woodfuel expertly places in the stoke holes heat the mounted pan which transfers the heat by conduction to the sifted cassava mash inside the pan. The pan is sometimes smeared with oil, usually palm oil, and the sifted material is spread thinly in the pan in lots of 2-3kg at a time and continually stirred to effect partial gelatinization of the starchy granules and is continued until a rusting sound is heard, indicating that the moisture has been driven off through drying. During the roasting period most of the cyanide is also driven off. The roasting operation lasts for 30-35 minutes and the resultant product, gari, which is about 20-25 per cent of the weight of the fresh cassava tubers and with a moisture content of 8-10 per cent, is gritty and granular, white or pale straw in colour with a slightly sour aroma and a characteristic taste. The determination of the end of the roasting operation depends largely on the experience and correct judgement of the processor in ascertaining the correct degree of crispness and colour of the resultant product. This method of roasting by women nay make them to suffer from either headaches, bodily pains, fever, heat rashes, diarrhoea, reddening of the eyes, profuse sweating or even miscarriage caused by the heat and smoke emanating from the roasting process. The vapour driven off during the process also contains some cyanide and the continuous inhaling of the vapour also presnts a health hazard to the processor. There is a high energy loss in most of the village gari roasting operation because of inadequate regulation of the wood fire intensity and therefore energy consumption per unit output of gari is relatively high.

3.18 Improved roasting units have however been incorporated in the NGO-funded cassava processing units in order to reduce the

discomfort suffered by village women processors and to improve on the energy consumption. Each such roasting unit consists of a hearth of burnt bricks laid out in a raised rectangular fashion with the top open and a chimney made of burnt bricks is attached to the rear which is outside the processing area. There are two stoke holes of rectangular cross-section below the hearth which serve as woodfuelling entrance, and the chimney allows the smoke from the woodfuel to exhaust. Roasting is done by two women standing beside the hearth and stirring continually lots of sifted mash in a shallow cast-iron or steel pan mounted on the hearth which is heated from below.

Sieving

3.19 Village processors do not normally sieve their gari unless the roasting process results in relatively large amounts of oversized gari particles. When this happens the traditional cane sieve is used, and the oversized partially-gelatinized particles are sundried and sold as animal feed.

Packaging

3.20 The gari is normally packaged in jute fibre sacks and stored in that way under prevailing ambient room conditions. Some of the gari is put into aluminium or enamel bowls. Due to the relatively poor packaging method due to non-air-tightness of the package, the gari picks up moisture in storage resulting in loss of crispness. Prolonged storage under prevailing ambient conditions therefore affects the gari adversely.

Agbelima production technology (Annex..2.....)

3.21 Agbelima (cassava dough) is the next processed cassava product. In terms of quantity, it is the leading product produced by most of the processing units because its production entails primarily the grating of the peeled and

washed cassava tubers and the subsequent fermentation of the resultant mash. Moreover, the handling, packaging and conveyance from the point of production to the point of sale, usually on market days involves the use of few baskets of various sizes and some enamel bowls and calico cloth. In essence, agbelima is far cheaper to produce and sell than gari. Unlike gari, agbelima is produced commercially for sale in most cases on specific market days in rural and urban centres.

3.22 In the production of agbelima the cassava mash is seeded with an innoculum made of previously fermented cassava pieces thereby reducing the fermentation period from 2 to 4 days to a day or less. The unstandardized innoculum is prepared in several ways, inter alia, as follows:

1) peeling and drying of cassava pieces for 2-3 days during which period they ferment;

2) wrapping of the cassava pieces for 2-3 days for them to ferment;

3) toasting, wrapping and aging of cassava pieces for 3-4 days for them to ferment;

4) submerging in water, wrapping and drying of cassava pieces for 3-4 days for them to ferment;

5) submerging the cassava pieces in water for 2-3 days to ferment and then drying for 3-4 days.

Apart from shortening the fermentation/dewatering operation the innoculant is supposed to break down the fibres in the cassava mash into very fine particles so as to make the dough smooth.

By-products

3.23 The main by-products obtained from the processing units are cassava peels which are either sold fresh or are sundried and packaged in jute fibre sacks and sold as feed for livestock in rural and urban markets, especially during market days. A lot more of the dried cassava peels is obtained from kokonte (dried cassava chips) production which involved the hand peeling of the cassava tubers and simultaneous sundrying of the edible portion and the peels.

In processing units where the cassava mash is pressed, either in a screw press or with loads of stones, a lot of milky juice comes out of the pressing operation as a by-product which is allowed to go waste. With improved pressing operation methods, this by-product can be collected and decanted to obtain starch which can even be modified to obtain glucose syrup.

Another by-product obtained from processing units which produce gari is agglomerates of large particles of gari which are partially gelatinized and dried and therefore have a higher moisture content. The gari particles agglomerates are usually sundried and sold as feed for livestock.

Classification of Processing Units

3.24 The method of operation classification groups all cassava processors with or without processing machines. The cassava processing units can be grouped according to either the "method of operation" or the "number and types of equipment used". In the method of operation group there are five main types of operators and in the number and types of equipment there are three main types of operators.

Method of Operation

First type of processors

3.25 The first type of processors in the method of operation group, roast, grated, dewatered fermented cassava mash along some major road networks (like the Accra-Kumasi road) and sell the resultant product, gari, on vending tables along the road. These garimakers are primarily raw cassava root sellers and whilst selling their wares peel some of the cassava, wash them and send them in enamel containers per their maids or children to custom-service milling houses located some 1-2km away for grating at a fee. From the miller the grated mash is either brought back to the vending site where it is loaded into polypropylene sacks which are then put wooden planks and dewatered and fermented for 1-2 days by piling heavy stones on the sacks or the dewatering and fermentation are done in similar manner at the custom millers' site. After dewatering and fermentation, sifting in traditional bamboo sieves followed by roasting in shallow concave metal pans placed on 3-point triangular-shaped stome stove are done, just behind the cassava selling areas. These road side cassava processors operate mostly when cassava is plentiful on the market and as a subsidiary income-generating activity to their main vocation which is selling of fresh cassava tubers.

3.26 There is another type of roadside cassava processors who operate along the untarmented Buipe-Damongo road. One of such types is at the village of Busunu in the Damongo District. These processors, who are not raw cassava vendors, grate the cassava tubers using hand held graters and dewater and ferment the mash traditionally with heavy stones loading near their compound houses, while sifting and roasting of the moist mash are done along the road. The sifting is done using traditional cane sieve and the roasting into gari is done in

shallow concave pan placed on a dugout fireplace into which the fuelwood is put, lighted and regulated. The roasting is done by women and at times children with the men helping when the wife is indisposed. The sifting and roasting are usually done under huge shady trees along the road, occasionally a shed may be erected for these activities, when a tree does not give good enough shade. Gari produced by these processors is fibrous due probably to the cassava used or the equipment and method of processing employed.

Second type processors

3.27 The second type of processors, which is a family unit as the first type, also gets their washed, peeled cassava roots grated in custom-service milling houses located some distances away or near the processing site as in Nkwabeng Sunyani district and Kwesimintin, Takoradi district but dewatering and fermentation are done with parallel board presses in a compound where sifting and roasting into gari take place under a shed or sheds. This type of processor is the most common and the custom-milling house is usually privately-owned and may be either only a single cassava grating machine or a grater-cum plate mill (corn mill) combination unit which gives common service to the community. In very limited cases the grating of the cassava is done in institution-owned plants, which have the full compliment of equipment apart from the grating machine to produce gari.

3.28 A variation of the second type of processors operates not in a village but in a suburb of the Kumasi Metropolitan Authority. These processors who operate in a large compound, near the Ghana Broadcasting Station, Kumasi, share the services of a common cassava grater which they either collectively own or is on hire to them from a manufacturer for which a monthly fee is paid for use. The group consists

of about 7 family units each possessing a parallel board press for dewaterisng and fermentation and 3-4 roasting bays under thatch roof sheds where gari is roasted in shallow pans placed on 3-point mud stoves. The open nature of the working compound favours the blowing of winds which greatly increases the rate of fuelwood consumption during the roasting process and also causes considerable smoke, emissions which affect the eyes of the women processors. About 60-70 per cent of cassava processors countrywide are in this category.

Third type of processors

3.29 A third type of processors, each of which is a family unit, have their own parallel board presses for dewatering and fermentation but have to hire a mobile cassava grating machine which the owner-operator brings to them on request on specific days. For grating jobs therefore, the processor has to inform the owner-operator of her need for the machine and pay in advance the cost of transporting the machine to and from the customer's site. Services for grating are charged according to the quantity of cassava grated. One of such type of processors operates in the Cape Coast district of the Central Region and the hiring mobile grating machine used has most of the components made of wood, and uses insecticide spray machine motor, which is self-starting, to transmit power to the grater. The surface of the pressure application wooden block ofsuch a grater gets worn out from frequent use of the machine and the wood chippings may even be incorporated into the grated cassava mash.

Fourth type of processors

3.30 The fourth type of processors operate under the aegis of a processing plant which have been donated by a non-governmental organisation (NGO) but whose operations are co-ordinated and/or managed by a local organisation or institution. Some of such plants are at Kwamoso, Ejisu District, Ashanti Region; Takla, Hodzo-Aviepe and Abutia-Teti, Ho District, Volta Region; all donated by Sasakawa Global 2000 and being managed by the 31st December Womens' Movement (31 DWM). Other such plants are at Hodzoga, Ho District, Volta Region, donated by Friedrich Ebert Foundation to the village Life Skills Improvement Programme, WHO/GOG project and being managed by a village committee at Dawa, Ada District, Greater-Accra Region, donated by UNDP and managed by Environmental Protection Council (EPC) with the assistance of a local committee.

3.31 Equipment for such processing plants set up primarily for gari production, usually comprises a drum-type, cassava grater or a disc-type grater as in the Dawa unit, a corn mill, a diesel engine or an electric motor as the power unit for both processing machines, two parallel board presses or a screw press as at Hodzoga. All the machines are usually housed in burnt bricks or concrete building with aluminium roofing which provides good ventilation. Except the Dawa unit which has to purchase water at times for processing purposes, all the other units have boreholes for water. Cassava processing is therefore very irregular at the Dawa unit.

The Kwamoso, Takla and Hodzo-Aviepe processing plants have roasting bays consisting of two rows of smokeless ovens made of burnt bricks with the chimneys outside the building. Roasting of the moist fermented cassava mash is done in two rectangular stainless steel pans placed on the ovens which are heated with lighted fuelwood fed through stoke holes beneath the stoves.

In Hodzoga however the roastisng unit is housed under a thatched roof shed outside the main concrete building accomodating the grater, the diesel engine, the corn mill, and the press. The roasting pans are square shaped and are placed on the burnt brick smokeless oven whose chimney is shorter than the roof of shed thus resulting in the blackening and burning of the thatch.

3.32 Unlike the other processing units in the fourth type of processors, gari production in Hodzo-Aviepe is well-organized. Thereare six groups of processors with 20 people mostly women in each group. A sizeable cassava farm or farms each about 16m x 16m is initially purchased by the groups as a whole. For processing the groups are organized as follows:

- the first group goes to the farm at about 0530hr. say on Monday and returns at 0800hr with harvested cassava. From 0800hr to 12.00 noon the group does peeling, washing, machine-grating, innoculating of the mash which is allowed to dewater and ferment for the following day.

- on the following day Tuesday, the first group starts sifting and roasting the moist fermented mash by 0800hrs and finishing at 18.00hrs.

- during the period when the first group is sifting and roasting the second group would be in the farm harvesting cassava which they bring to the processing site, work on it up to 12.00 noon and sift and roast the mash the following day, Wednesday.

In effect each group works effectively for two consecutive days to produce 1.5 mini bags of gari from 3-4 mini bags of dewatered fermented mash. Within a working week of 6 days, ie. Monday to Saturday, five groups participate in the gari

production, leaving the sixth group to commence the production procedure the Monday following.

In the Hodzo-Aviepe plant and other plants which are fully equipped cassava dough (agbelima) production is a secondary occupation and is produced more or less by individual members of the groups to meet specific local market days' demands. Besides, cassava peel by-product is usually shared to individual peelers who need them as feed for their livestock.

In addition to the standard cassava processing equipment found in NGO funded establishments, the Hodzo-Aviepe unit has a peeling table, an additional parallel board press and a cassava root washing bay outside the plant but near a storage tank which acts as a reservior for water.

3.33 A varied version of the fourth type of processors operate in the Korluedor village, Ada District, Greater-Accra region. Here the processing wooden building accommodates two roasting bays and a diesel engine which is connected by a pulley and a flat belt to a drum-type cassava grater mounted on a concrete patio outside the building. A screw press is also mounted at one and of the patio. The arrangement of the grater and the press outside although exposes the two machines to the vagaries of the weather, facilitates the primary customer-service function of the processing unit. The construction of the patio with its drainage channels for extracted cassava juice helps in maintaining a relatively good sanitary environment in the processing unit which belongs to the Christian Mothers' Association of the Catholic Church, Tema district. Due to poor construction the roasting bays are not in use and therefore moist fermented mash roasting into gari takes place under a thatch roof shed erected some 200m away.

Fifth type of processors

3.34 The fifth type of processors comprises producers of agbelima (cassava dough) which is obtained by grating the cassava roots in mechanical graters and fermenting the resulting mash in the traditional way of pilling stones on the bagged mash. These agbelima producers are the largest of cassava processors in terms of numbers of operators and in terms of volumes of product. These operators are found anywhere a mechanical cassava grater is installed. Their mode of operation is as follows:

- large cane baskets with volumes varying between 0.2 - 0.3m³ Annex. 3 ... are obtained and deposited on a special constructed concrete patio in front of the building housing the cassava grater and other machines;

- the baskets are filled frequently by either the owner of the basket and her children or by hired labour, with small quantities of freshly peeled and washed cassava roots until the baskets are fairly full;

- grating of the cassava usually starts about 18.00 hrs. in most cases when the owners of the filled baskets are present at the processing site and continues for 2-4 hours depending on the quantities of roots available;

- the grated mash is loaded into the large baskets while the cassava is being grated and the mash is manually pressed to squeeze out some of the liquor;

- the mash is later loaded into polypropylene sacks and dewatered and fermented for a day or two after it has been seeded with appropriate innoculum in many cases.

- payment for grating is determined by measuring the volume of cassava grated by means of a special basket 0.01 m^3 in volume Annex. 3 .. which is loaded over the brim in a conical fashion to represent the unit of fee charged by the miller.

3.35 Agbelima producers are concentrated mostly in the Greater Accra, Eastern and Volta Regions with the largest group concentration in Kaseh market, Ada District, Greater Accra Region, where there are ten cassava grating-cum-corn milling machine units which give custom service to the producers. Each of the units has a concrete patio in front of its shed where each set of machines is housed and is used for dewatering and fermenting the cassava mash. The size of each patio is however small and cannot therefore cater for the large volumes of agbelima produced. Consequently the producers resort to using the large open spaces in front of the custom service milling units for dewatering and fermenting their cassava mash. With the uncontrolled spillage nature of the milky juice from the dewatering/fermenting process these open spaces become very soggy and unsanitary and a breeding ground for flies of all kinds, creating an environmental problem.

3.36 Seventy per cent of the cassava graters used in the Kaseh market for agbelima production is the cylindrical type with a wooden rectangular box-like hopper fabricated by a local carpenter/blacksmith. The hopper rests on two end-bearing blocks which accomodates the shaft of the grating rotor Raw cassava is loaded into the hopper and after grating falls below the hopper and the rotor into an inclined concrete trough from which the mash is scooped into enamel basins and then loaded in polypropylene sacks for subsequent dewatering and fermentating.

Number and type of equipment

3.37 In the number and types of equipment group of classification account is not taken of the processors as such but rather the facilities used for processing the cassava. In this classification there are three main groups or types operating.

First facilities group

3.38 The first group comprises procesing units with a cassava grater powered by either a diesel engine or an electric motor both of which may be housed in a wooden building or the grater may be outside the building but connected to the prime mover by means of belt and pulley transmission. The main function of such units is to give custom service to cassava processors.

Second facilities group

3.39 The second group of processing units have a grater and a plate mill (corn mill) each of which is run alternately by either a diesel engine or an electric motor. In most cases both size-reduction machines and the prime mover are all housed in a wooden building. In very few cases the grater may be outside the building. The primary function of this group is to give custom service to both cassava processors and maize millers. The group is the most common because of the additional income generated from serving non-cassava processors who may be more frequent at the processing site with their small quantities of maize for milling.

Third facilities group

3.40 The third group of processing units comprises the non-governmental organization (NGO) funded units which have a grater, a corn mill, a press, roasting bays and a diesel engine or an electric motor as the prime mover for the two size-reduction machines and in most cases a borehole for water. The primary function of this group is to produce gari for distribution by their local management organisation. The number of units operating in this group is very small and may be less than twenty country wide.

Kokonte Production

3.41 Apart from gari and agbelima which are produced by woman and family units in most villages of Southern Ghana, "kokonte" fermented cassava chips, is also produced even more countrywide than gari and agbelima since many households in urban and rural communities tend to indulge in its production because it does not need any skill or any processing equipment traditionally for its production. Consequently, kokonte can be seen being produced by sundrying cassava chips on roadsides roof tops, in market places, on concrete constructions and elevated structures in and around various homes all over the country. Such traditional method of kokonte production exposes the final products to all sorts of external contamination even from human beings. Most, if not all, the kokonte produced in this way is for household consumption and do not enter into commerce, to any appreciable degree.

3.42 The bulk of commercial production of kokonte is undertaken in the northern parts of Brong-Ahafo Region and throughout the Northern Region except Walewale and Gambaga districts

which are in, the transitional zone between Northern and Upper Regions and which do not grow cassava. The production areas have very favourable weather during the drying period of the cassava chips. This weather, the harmattan, which consists of dry northwesternly winds, facilitates the sundrying of the large chunks of peeled cassava destined to become kokonte. Sizeable quantities of kokonte are also produced on commercial scale in the Ada district of the Greater Accra Region but the bulk of the commercial production is obtained from the aforementioned northern parts of Ghana.

3.43 The processing technology employed to produce kokonte in the village of the northern parts of Brong-Ahafo Region and in Northern Region are similar but with slight variations which do not affect significantly the quality of the kokonte produced. The general processing technology which is shown in a flow diagram in Annex..2.... is as follows.

- Cassava, mostly the 12-month maturing variety, is harvested about the fourth week in December and early January when the ground is soft enough after the rains for uprooting by hand and are then peeled with sharp cutlasses by the farmers and their families, hired labour being used when the harvest is abundant.

- The peeled roots are then cut lengthwise into two or four pieces which are spread out to dry on either cassava sticks or leaves, sorghum stalks made into mats or on raised platform made of sticks covered with thatch. Depending on the weather and on the sizes of the pieces the drying takes between 2 - 8 weeks. In any case by the end of February the cassava pieces are fairly dry to a low moisture content of about 10 per cent (wet basis). The cassava pieces or chips are

collected afterwards and conveyed as head loads or by tractors with trailers to the villages for storage in barns called "Kanborn" in Lumo village.

3.44 In some villages such as Lumo and Tampei Kukuo, in the Tamale district of the Northern Region, the cut cassava pieces are dried on raised platforms either on the farms or in the village because of theft by sheep and goats which are reared in the village. However most large-scale "kokonte" producers in the two regions generally do not bring the bulk of their peeled cassava to the village for drying due to the large quantities involved and only bring small quantities to dry on raised platforms mainly for home consumption. A typical raised platform which is used to dry partially-dried cassava pieces carted from the farm to the village may be 5.3m long, 4.8m wide, and 2.8m - 3.0m high.

The platform called "leinga" in Lumo village consists of about eight strong sticks or poles forked at the top which is overlaid with horizontal drying platform made of woven sorghum stalks mat or of sticks covered with sorghum stalks. The sticks making the platform are tied with tie-vine to each other and the end sticks are tied to the uprights. A ladder made of sticks and tie-vine is used for climbing up to spread the cassava pieces (kokonte) on the platform. The vertical sticks or poles are replaced seasonally when weak. Drying on the leinga takes about eight weeks from the time of peeling of the cassava. When thoroughly dried, the kokonte is collected and stored in a kanborn or barn, Annex.....

3.45 The barn, or kanborn is the most common storage structure for kokonte in northern parts of Brong-Ahafo and Northern regions. It consist of a base made of strong thick sticks which are arranged radially and tied together by tie-vine in an inverted umbrella shape. The base is usually erected on

a stand consisting of short thick tree trunks 0.3 - 0.5m high. The base is built low in order that no animal predators can stand under the barn to eat stored product and in such a way that the bottom is not wetted by rainfall unless there is a flood. In between the radially-spaced sticks strong upright sticks are erected and tied in such a way as to prevent movement. The number of uprights, which are usually imbedded into the ground, depends on the circumference of the base. For a barn of 5.8m circumference, 1.4m high and having a stand of 0.3m the number of upright sticks is 12. The cylindrical framework is usually covered with woven mats of sorghum stalks and the top is covered with a conically-shaped thatch roof also made of sorghum stalks. The completed barn to takes a minimum of 8 person-days, working 12 hours a day to construct. It is however constructed in most cases either by a family group or communally and in this way the completion period is shorter. Usually the sorghum stalks used for the covering is cut and piled up in the farm to dry and is brought to the village to be used when enough is obtained. A new barn is built every 2 or 3 years when the straw covering the thatch roof and sticks are weak.

Large-scale kokonte producers are able to construct and fully fill four large barns with kokonte in seasons when cassava productions is good. Generally however the number of barns is two per household.

The effective height of a barn measured from the gird or rim of the base to the top of the cylindrical part, varies from 1.4m - 1.7m and the circumference 5.8m - 8.9m. The effective cylindrical volume is between 3.75m^3 to 10.7m^3. Estimates show that a barn of 10.7m^3 can accommodate a maximum of two trips of tractor load of kokonte which amounts to 60 maxi jute fibre sacks, as any additional load may burst the sides and fracture the framework.

3.46 Depending on the moisture content, the kokonte can stay in the barn till the next harvest season or for at least 12 months but it is usually infested while in storage by weevils and/or Larger Grain Borer (LGB) which bore holes in the stored product through which they enter and eat it, reducing a considerable quantity to powder by the 7th month of storage.

3.47 In Tampei-Kukuo and other villages, kokonte is also stored in mud rooms after being dried on raised platforms, the storage room, which is usually cylidrical in shape and covered with thatch roof, is 5m in circumference and 1.5m high, with volume of $3m^3$. It has a door opening 0.6m high and 0.5m wide. The wall thickness is about 0.15m. The construction material is sun-dried mud or clay bricks which are moulded by men and dried for 7 days. For a storage room of such dimensions about 250 sundried standard bricks were used in its construction and it takes 3 person-days to build. When mud is used in construction such a room it usually takes 9 person-days to complete. No sticks or grass is added as a mixture when mud is used in the construction. The a storage room is normally constructed inside the compound house, typical in the Northern Region, to prevent flood water destroying it. When filling the storage room to the brim with kokonte, the thatch roof is removed, the door is closed and the kokonte is poured in from the top which is later covered with the thatch. The thatch roof is usually replaces with a new one when it decays. Termite attack of kokonte in room store is common and may even affect the store itself. With good housekeeping and maintenance practices the mud-brick room store can have a life span of up to 10 years. The Tampei-Kukuo store which is estimated to have a capacity of 20 maxi jute sacks is already 5 years old ;and shows no signs of cracks due to weather conditions.

3.48 In an effort to improve the storage of kokonte the Post-Harvest Development Unit (PHDU) of the Crops Services Department and the Extensions Services Department both of MOFA have constructed an improved kokonte storage demonstration barn on the compound of a farmer. The barn which is 9.2m in circumference, 1.2m high with a leg 1.0m from the ground has a capacity of about 8.1m^3. The legs are fitted with 0.3m high rat guards made of 4.5 litre oil metal containers the top and bottom of the guards being 0.9m and 0.6m from the ground respectively. The barn is estimated to accommodate 40 maxi jute fibre sacks of kokonte the quantity of which causes the sides of the barn to bulge. To prevent the barn from collapsing strong sticks are used to wedge the sides.

From estimations a barn with a capacity of 8.1m can carry a load of about 45 maxi jute fibre sacks of kokonte, and therefore any exhibition of collapse of such a barn can be attributed to such factors as high bulk density of the kokonte due to its high moisture content, weak compressive strength of the construction materials for the raised bottom floor and sides of the barn, and the manner of loading of the kokonte into the barn.

3.49 In addition to the barn, the PHDU of MOFA has constructed a demonstration storage crib made of sawn timber, similar to those used for maize storage, on the compounds of the same farmer and another farmer nearby. A similar storage structure has been constructed in the village of Tampei-Kukuo. Indications are that one such crib has also been built at Yipala village in the Damongo district. The dimensions of the storage crib in the villages are 1.5m wide, 2 - 3.5m high (front) and 1.4 - 3m high (rear) with a drying/storage platform 1m from the groundand an overall length of 4m. The legs are covered with rat guards.

Also on the same compound, a plain concrete floor for drying patio, 4m x 5m with a depth of 3.0cm has been constructed as an additional demonstration facility to the crib for drying of kokonte.

The design of the barns in the various villages are similar but they are not standardized as their sizes, quantities of construction materials used and their capacities vary widely.

The drying patio constructed apparently to encourage farmers to construct similar structures for drying of their cassava chips is useful although it restricts air flow around the chips and thus reduces the rate of drying. A black-painted cement floor is better than a plain cement floor as it gives shorter drying times due to the heat retention nature of the blackened surface.

Capacity Utilization of Cassava Processing Units

3.50 The capacity of a cassava processing unit such as a grating machine or a processing plant can be defined in terms of both the quantity of cassava that it is possible to process in an hour or a number of hours (for example 24-hour period) and the number of hours or days that it is possible to operate over a longer period of time (for example a year). The narrow hourly definition does not allow for time lost through maintenance work and the need to observe public and annual holidays.

3.51 Custom service single cassava grating units work intermittently and a few hours and only during the day because they are either family-owned or individually-owned and operated and also because they require customer participation. Custom grating units also need neither to adhere to statutory holidays or carry out extensive

maintenance programme. The effective hourly capacity of the custom unit also depends on a number of factors. For example if the volume of cassava to be grated comprises a large number of small quantities, lost production time is greater than if it comprises a smaller number of large quantities because the unit has to run empty each time a customer's cassava is processed before the cassava of the next customer is fed into the grater. The rating given by manufacturers of the cassava grater however assumes continuous operation which is at variance with practical realities.

3.52 Processing plants funded by NGOs, also do not operate continuously for 24 hours a day or even a few hours each day in a week. In fact the operations of these plants are erratic. For example, a plant is operated at times only when a customer brings cassava for grating or pressing necessitating the use of the grater or press. In most cases grating of cassava for customers is the only activity undertaken by these plants - which make them custom-grating houses rather than processing plants where the full range of cassava processing operations is carried out. Occasionally these plants operate to process their own cassava into gari and agbelima but these activities are few and far between. Often the operations of these plants are left in the hands of local semi-skilled and unskilled personnel who are engaged in other personal vocations. Proper supervision of the plants' operations are therefore lacking as in many cases the overall supervisor or manager of the plant may be residing in the district or regional capital far removed from the plants. These processing plants are therefore idle for most of the time.

3.53 The individually-owned processing units comparatively have relatively higher capacity utilization efficient than the NGO units although they depend wholly on customer participation

for their operations. This is so because, in most cases, these units, which are private, are sited in such areas as market places, centres of villages or town, or near main road networks, where they are more easily accessible to customers. In addition unlike the NGO funded institution-owned units, the individually-owned units although they work intermittently, operate almost daily since they need neither conform to government laid down regulations of number of working hours a day nor adhere to statutory holidays and staff leave rosters.

A great deal of excess capacity is therefore available at the cassava processing units especially the NGO funded institution-owned plants.

B. Yam Processing and Preservation

Processing

3.54 Yams are grown in most regions of Ghana except the Upper East region. However, the largest yam production areas are in the Northern Region. Despite its widespread cultivation which has ever been boosted by the introduction of the miniset production technique, yams are not processed in any appreciable quantities in the villages. Apart from boiling and eating as "ampesi", pounding into fufu, roasting and frying, the only product from yam which is traditionally processed and marketed on a regular basis is "Wasawasa". However yams are prepared in various forms occasionally mainly for home consumption. Some of these traditional forms are:

- Oto (Twi, Fanti, Ga), Etetugu, Etenyanya (Ewe), which is mashed yam with palm oil and hard-boiled eggs. The oil is mixed with the yam after cooking and mashing and the

eggs after boiling are peeled and put on top of the mash. Sometimes tomato and onion are fried in the oil and added to the yam. This is a festival dish.

- Mpotompoto (Twi), Kpotonkpoto (Ga) Mpotoe Tedzogboe (Ewe) is a yam porridge. Yam is peeled and cut into cubes which are then boiled with meat and/or smoked fish, onions and tomatoes in a fairly large volume of water. Sometimes more onions fried in palm oil are added. The yam pieces may be mashed into the liquid or left in as such. Mpotompoto is sometimes made simply with yams and a little palm oil.

Yam flour/yam kokonte - which is made from the heads "of yams which take longer to cook than the rest and are therefore not commonly cooked when making ampesi or fufu. It may also be made from any yam which shows signs of rotting. Yam flour is cooked like cassava kokonte or made into "wasawasa".

Wasawasa production

3.55 Wasawasa is made from the hard heads of yams, the large peels and whole yams which shows signs of rotting. The processing technique is as follows:

- Yam heads, pieces and peels are sundried to a very low moisture content below 10 per cent. They are then pounded in a mortar and later sent to custom milling unit (corn mill) and ground into flour.

- Back in the house, the flour is put into a large calabash and water is added to moisten it. The damped flour is then either shaken in the calabash until it becomes rolled into tiny balls or the fingers are used to mixed and work it out into tiny balls.

- The tiny balls are then steamed in a perforated earther pot over boiling water in another earthern port, the upper steam producing pot being covered with a lid while the interface between the perforated bottom of the upper pot and the open top part of the lower pot is sealed with flour mixed with water.

- When cooked, the food is poured out into a bowl, water is added and it is then washed in such a manner as to separate into single ball units which are then steamed in the same way as the first steaming. The whole process takes about 90 minutes. Before the second steaming a check is often made of the water content in the lower pot and if it is not enough additional water is added through the bottom perforations of the upper pot so as to ensure that the water in the lower pot does not get finished during the second steaming procsess.

- After the second steaming some oil, is heated together with onions a bit of pepper, and salt is added to taste. This concoction is then mixed with the steamed balls to make "wasawasa". Wasawasa is sold mostly on village market days in the Northern and Upper Regions of Ghana.

Preservation /Storage

3.56 The bulk of yams produced in the villages and in Ghana in general, are preserved in the raw form by storage. Various methods and structure are used for the storage which vary considerably in design and construction in different parts of the country.

3.57 In the drier areas of Ghana, namely the Northern and Upper Regions and Northern Parts of Brong-Ahafo, the yams are stored in the field and in farm compounds.

In the field, an extremely simple mode of storage consists of merely stacking the tubers in small heaps, after lifting, on the ground under the cool shade of a huge tree and covering with grass, sorghum or millet stalks or mats made of the same materials.
A second covering of thorny branches and tree twigs are put on top of the first covering to prevent predators from getting to the stored product.

3.58 In some villages, yams are stored in the crevices, in outcrops of rocks or between "buttresses" of large trees such as the silk-cotton trees where there is some protection from the sun or flooding. Usually individual stocks would normally contain only a few dozen tubers, so that even those in the interior receive adequate ventilation. Yams stored in the field in this way are not likely to be adversely affected by exposure to the climatic conditions, but are susceptible to termite or rodent attack, and unless the site is closely supervised theft by humans and monkeys is liable to occur.

3.59 Yams are also stored in pits in the villages. The pit about 0.5m deep and of suitable length is dug into a hill side or in a well-drained spot and is lined with dry grass or straw. Sound tubers are packed into the pit and covered with straw, followed by 10-20 centimeters of sod and earth. To reduce respiratory self-heating, an opening, which is stuffed with straw, is either left in the centre of the mound or a hollow bamboo stick is inserted in the centre of the mound.

3.60 Yams intended for home consumption are also stored above ground in mounds and may contain up to 150 tubers. The tubers may either be attached or detached from the vines.

3.61 In the Upper West Region villages of Bulenga, Boli, Vieri, etc. where a lot of yams are cultivated and harvested in October/November, small thatched huts of simple mud huts are often built near dwelling houses specially for yams. These mud huts are usually rectangular in shape with a small opening as entrance through which one has to crawl to enter. Inside these huts the tubers are stacked in heaps on the floor. It is however preferable that the tubers are supported on racks to ensure adequate ventilation and to prevent the spread of storage rot.

3.62 In some villages in the Northern Region such as Lumo, yam tubers are stored in barns in the field. Each barn, which is cylindrical in shape, is made of woven sorghum stalks mats framework and the top is covered with a conically-shaped or nearly flat thatch while the bottom sits on the ground. To hold the framework erect and prevent it from sagging, it is tied to vertical sticks with tie-vines, 10-15cm in diameter. The barns are constructed in the farms so as to facilitate the handling and storage of the bulk of the harvested yam. The weave of the mats is such that there is a lot of ventilation and this renders the inside of the barn relatively cool. Each barn has a disguised entrance which is hardly distinguishable from the barn framework. The sizes of the barns vary considerably depending on the size of the harvest. At times twin barns are built in such a manner that the exterior face of one becomes part of the interior face of the adjoining one. In such constructions there are savings in construction materials and labour input. The barns are normally fenced with dry twigs to ward of predators such as goats and sheep but the fence is not a deterrent to rodents which bore holes at the bottom of the barns through which they enter to do damage to stored yams. Different types and sizes of both ware and seed yams are stored in the same barn. The yams are heaped on the floor

of the barn, at times against the framework, different sizes of the same type of yams being stored together.
Within the barn the yams are stored for 12 months or more from one harvesting season to the next planting season.

3.63 Sprouting is a major problems in these barns and it leads to the exhaustion of the food stored in the yam. Sprouting can be delayed by cutting or breaking off the yam heads before curing and storage. Tubers which are being stored for replanting need not have their head removed. Planting yams need only to be trimmed short regularly.

3.64 In the high rainfall forest zone the yams are stored in shaded barns where they are tied to racks and poles. The important features of the barns in the forest areas include shade, good ventilation, strong supports and secure walls. Shade is given by either live or dead plant material or from iron or aluminium sheeting. Live shade is obtained by planting posts of fast growing trees along the racks and around the outside. In some cases shading is provided from palm leaves and grass. The yams have good ventilation and this improves their storage. Inside the barns there are racks of vertical supports and vertical uprights made from stripped palm branches, split or strong sticks, built in lines, and the yams are tied to these uprights, with tie-vine or string. The walls of the barn are made in stockade fashion from bamboo or wooden poles and are secure enough as protection against goats, rats and thieves. Tight fitting doors are also usually fitted as additional protection.
Inside some of the barns there are simple open work shelves In one such barn in Hodzoga, Ho district, Volta Region, the shelves are 3-tier and most of the yams are properly arranged on the top two shelves while the rest are heaped on the bottom shelves. Shelving of yams requires less time and labour than tying and has the advantage of facilitating

regular inspection and the removal and disposition of insect-infested tubers.

C. Cocoyam Processing and Preservation

Processing

3.65 Cocoyam is peeled and cooked mixed with cassava or plantain and eaten as "ampesi". It is also pounded mixed with cassava into "fufu" after peeling and cooking together both types of tubers.

In addition to its use in ampesi and fufu, cocoyam is often roasted in fire before peeling in the villages. Pieces of the tubers are also roasted on locally-made charcoal-ash-grilled roasters along main road networks in villages.

Cocoyam, like yam, is also made into cocoyam porridge, Mpotompoto (Twi). There is no major processing of cocoyam for commercial purposes.

3.66 In southern Ghana the most common form of spinach kontomire or nkontomire, is cocoyam leaves. These are eaten especially by people in the forest zone who may take nkontomire stew or soup almost everyday, particularly in the villages. The leaves are washed, broken up and boiled for at least 20 minutes or longer till soft. They are then mashed, usually with a wooden spoon in a special eartherware bowl which has close-set ridges on the inside. The mashed pulp is put back in the soup or stew and a little water added to thin it.

Preservation/Storage

3.67 There are no definite storage methods for cocoyam in the villages. The tuber is often left in the ground and harvested when required. After harvesting the crop is stacked in piles and covered with banana leaves in a shady place. Storage in baskets in houses is common. At times the tubers are stored in dug-out pits.

3.68 Rots at different stages of development occur in cocoyam kept in storage. The rots are of two main types - dry rot and wet rot. The diseased tissue in the case of dry rot is dry, firm or caky, and in the wet rot, the diseased tissue is soft and frequently wet. The colour of the cocoyam tissue colour during the cause of the rot, changes progressively from cream white to various shades of brown or gray, terminating in dark brown or gray-blue. The rots are initiated mostly from wounds arising from detachments from cormels, other corms and harvest bruises.
Sprouting is also a common problem with cocoyam storage especially when held under moist conditions.

D. Sweet Potato Processing and Preservation

Processing

3.69 Sweet potatoes are usually boiled unpeeled or roasted in hot ash for food. They are also fried.
In the Upper East Region, the sweet potatoes are cut into pieces and boiled with tomatoes, onion and meat to make a local dish 'petepete'

Preservation/Storage

3.70 After maturing the sweet potato tuber cannot be left for long in the ground as a way of storing like the cocoyam because it is attacked by pests such as nematodes which cause storage rot. The tubers are also attacked by weevils which tunnel through harvested tubers causing rot.

3.71 Sweet potatoes which are to be used as seed, are stored by burying them in soil after harvesting. If there is moisture such tubers sprout. The tubers are also stored, usually under a shady tree, in dug-out pits lined with thatch, which are at times watered periodically. In some cases the pits may be left uncovered if there is no danger of theft. Due to the periodic watering the tubers tend to sprout a lot in storage.

In the Navrongo area of the Kassena-Nankani District small quantities of sweet potatoes are stored in earthenware pots after parboiling and sundrying. After a period of 3 months such tubers are removed from the pot sundried and put back into the pot. In the storage pot the sweet potatos can be kept for 9 months till the next planting season, part of course being used during the storage period.

E. Frafra Potato Processing and Preservation

Processing , preservation/storage

3.72 The frafra potatoes are mainly grown in very small quantities for household consumption. Part of the harvested produce especially the bruised ones, is boiled and eaten and the rest stored in various ways for later consumption.

3.73 After harvesting the small thin-skimmed tubers (the sizes of pebbles) are sorted according to sizes and absence of bruises, and are treated and stored in several ways. Some are selected for food and others for seed.

3.74 Some of those selected for food which are not eaten immediately are peeled by adding sand to them and stamping on them. The peeled tubers are then parboiled in a pot of water for 10-15 minutes the water is drained and the small pieces of tuber are sundried in a sand-free ground to a very low moisture content, the drying period depending on the ambient conditions. After drying the tubers are stored in earthenware pots which are tightly covered or sealed with lids cemented with cow dung. At times the storage pots are tied around their necks with ropes and are hung on tree branches. After 2-3 months those tubers which have not been consumed are put out to dry again in the sun and are put back into the pots. The process, which is to prevent spoilage, is repeated several times till the next harvesting season.

3.75 Undamaged frafra potatoes are usually selected for seed. These are thoroughly cleaned by removing adhering soil and then sundried for 2-3 days. When thoroughly dry, they are treated with wood ash which is poured on and mixed with the tubers. The treated tubers are then put into earthern pots which are sealed with mud.

3..76 In some cases tubers selected for seed are simply put in earthen pots, then covered with millet stalks and hung, by means of a rope or tie-vines, on tree branches where they sprout and are later planted.

In other cases, the selected tubers are stored in specially-woven grass mats which allow ventilation so that the potatoes do not get dessicated.

3.77 Frafra potatoes are also sometimes stored by mixing with groundnut shells in earthen pots which are covered and then hung on a tree branch.

3.78 Tubers meant for seed, are also stored by putting them on dry leaves which are laid on tie-vine, then rolled and tied and finally hung in a forked branch of a tree and left there till the next planting season, 8-9 months later.

3.79 The tubers are also stored in circular or rectanguar trenches dug under shady trees, especially in the Kassenah Nankani District Upper East Region, where they are produced in appreciable quantities. After treating with wood ash, the frafra potatoes are put into a trench and covered first with small sticks and then with wet soil. A trench is usually opened when potatoes are required and is closed soon after the needed quantity is withdrawn.

F. Distribution and Marketing

Cassava products

3.80 The three main cassava products, gari, agbelima and kokonte and the fourth (are by-product, peels, are distributed and marketed through two main channels - agents or bulk purchasers and direct sales to customers.
The bulk of gari produced by NGO processing units is packaged in jute fibre sacks, distributed and marketed by the headquarters of the organization, represented in mostly cases by their regional offices. One of such NGO's is the 31st December Women's Movwement (31 DWM) which distributes and markets gari from their cassava processing plants

scattered in the country. Gari from these plants are sold to some secondary schools, other institutions and to mostly armed forces units all over the country. Transport for distribution is provided jointly by the 31DWM and the particular institution concerned.

At times the 31DWM purchases gari from private producers to supplement supplies from their plants for distribution and marketing. There is therefore no problem with the marketing and distribution of gari with the NGO cassava processing plants.

3.81 The other bulk purchasers of gari are individual market mammies who contract private cassava processing units to produce gari for them. The mammies often travel to the units to collect their bulk consignment which they distribute mostly on wholesale basis to their retail customers during market days in large towns and cities. The price paid for the gari varies widely from 25-30 dollar per maxi bag ie. 50 American "Olonka" gallon tins during November to April when there is a plenty of fresh foodstuff on the market to 35-40 dollars when there is less food on the market and when it is even difficult to uproot cassava because of hardness of the ground during the dry season period.

3.82 Direct sales of gari to the public in the villages and along main road networks are undertaken both by producers and retailers. Such gari is often packaged in low density polyethylene pouches about 2 mil gauge. Some producers also bring their gari wares to sell in enamel bowls. Most market gari retailers also sell the gari in enamel bowls, exposing the gari to environmental conditions with consequent reduction in its crispness.

3.83 Bulk sales of agbelima are done either at the processing site or at specific markets on market days. At both the processing site and at the markets there is a standard basket which is used as the unit of sale. Most of the agbelima procuders undertake their own marketing and distribution by packaging the product in polypropylene sacks or baskets placing them in enamel bowls and conveying them by means of vehicles to the marketing centres.

It is usual to find all agbelima sellers congregated at about the same area in markets where they sell their wares. This is partly for the convenience of customers and partly to prevent the spread of flies which hover around the agbelima from spreading to other parts of the market. In villages where the agbelima is produced in nearby processing units such as in Kaseh, headloading or wheel carts are used to convey the product to the selling points.

3.84 The bulk of kokonte produced in the northern parts of Brong-Ahafo region and in the Northern region is sold to customers from Techiman, Wa, Kumasi and Accra who travel to the producing villages to purchase the product. The kokonte is normally packaged in jute fibre sacks and are priced at 6 - 7.5 dollars during the production season around March, and 10.0 - 12.5 dollars or higher during the lean season around July.
A lot of kokonte is also produced and sold in the Ada area especially on market days in Kaseh. Sometimes part of the bulk of the kokonte sold in Kaseh market is obtained from the Techiman market.

3.85 Cassava peels, obtained from the production of kokonte, are dried simultaneously with the cassava chips and they are suitably bagged for sale as livestock feed on market days especially in Techiman and Kaseh. Apart from selling in

bulk in jute bags by vendors, small quantities of the dried peels are also sold in baskets.

Yam and Yam Products

3.86 Yams are sold in yam producing areas in batches of one hundred to bulk purchasers or agents from Accra, Kumasi etc. who cart them to yam markets mostly in large towns and cities. Where the road is good, heavy duty trucks up to 10-ton capacity are used to cart the yams from the storage units on the farm. Where the road is not good either tractors are hired to go to the storage site to cart the yams to the trucks or women are hired to convey the yams as headloads to the trucks. In some cases the women have to cross streams to bring the yams to the trucks at the opposite bank of the streams. Where there are river boats they are used to cart the yams to the waiting trucks at the banks.

For small-scale producers the sale of their yams is timed to concide with village market days.
Yam ampesi, roasted yam and wasawasa are sold on regular basis in and around market centres especially during the harvesting season. Roasted yam are frequently sold along the roadsides especially where people usually congregate for one reason or another.

Cocoyam and Cocoyam Products

3.87 The bulk of cocoyam distributed and marketed, whether along road networks or in the market, is relatively fresh and may be only a day or two old after harvest. This is so because the leaves which are also sold and used as spinach, (nkontomire) need to be fresh to be purchased. Moreover, if the tubers are harvested and the leaves are separated

from them the leaves start yellowing which besides not being attractive to buyers reduces its vitamin C nutritive value.

Bulk purchases of cocoyam tubers and leaves are made by agents and transported to main markets in Accra and Kumasi and distributed to retailers. Consideraboe quantities of the fresh tuber and leaves are also sold in the villages along main road networks.

Cocoyam ampesi are sold in restaurants while roasted cocoyam and fried cocoyam are produced and sold in and around markets.

Sweet Potato and Sweet Potato Products

3.88 A considerable quantity of sweet potatoes is sold on market days in large towns and in city markets. Large quantities are also sold along such main road such as the Mankesim - Cape Coast section of the Accra - Takoradi highway. Fried sweet potato is sold in various centres in large towns and in the cities.

Frafra potato

3.89 The frafra potato (or Salaga potato) is produced on a small scale primary as a backyard crop. As a cash crop the quantities which are sold on market days in the Northern Region are relatively small.

G. Evaluation of Locally-produced Small Scale Equipment for Root and Tuber Crops Processing and Preservation and their manufacture

Workshop and facilities

3.90 The survey shows that there exists a good technological base for the manufacture of manually-operated and power-operated equipment such as cassava screw presses, cassava graters and other food processing equipment.
There are three main categories of manufacturers in this regard.

3.91 The first group consists of small to medium size industrial enterprises which have very well-equipped workshops where production involves forging, foundry work, metal working, welding, machining, heat treatment and production assembling thus employing relatively more modern technology in their production process. Most of the equipment used consists of machine tools powered by electricity. Food processing machines including cassava graters and cassava screw presses are among their primary products.

3.92 The second group of manufactures are small-scale artisanal shops with a fairly sizeable range of machines and tools such as grinders, gas and electric welding sets, electric drills, hammers, files etc. Their activities include sheet metal tube forming, metal cutting, machining and assembling. Some of the operators in this category may have lathes and hydraulic presses. The range of products of this group include primarily food processing equipment of which cassava graters and presses are same.

3.93 The third group are mostly blacksmiths and mechanics who are found in the rural and urban areas. Their production processes are based mostly on sheet-metal and tube working, forging and general bench-fitting activities in the form of filing. They use mainly hand tools such as hammers, chisels, punches or hacksaws in their operation. Table mounted or pedestal drills are also frequently used. Other facilities they may have include an anvil and a bench vice. A part of this group which is in the urban areas have access to electricity supply which they use in their fabrication jobs while their counterparts in the rural areas source of energy is charcoal and palm kernel shells which they use to fire the earth hearth. Those in the urban areas are therefore able to fabricate cassava graters, some components of which need welding.

3.94 There is a fourth category of manufacturers who are mostly farmers who construct various structures for the storage of their harvested produce. Their construction equipment consists essentially of hand tools such as cutlasses, pickaxes etc. which they normally use for their farming activities. Their products include yam barns, earthen silos, mud rooms etc. and their construction materials are sundried mud bricks, sticks, bamboo, sorghum stalks, tie-vine and local cordage material such as raffia.

Layout

3.95 Most of the equipment production workshops lack suitable layout of plants. This is due mainly to lack of space and the inability to organize production in an orderly manner. In order to increase productivity there is the need for good plant layout for increase operational efficiency.

Design, Drawing and Standardization

3.96 The machines which are produced especially the cassava graters and the cassava presses are found to serve rural communities efficiently because the designs are suitable to process raw material capacities in these areas. With increase in agricultural production, especially root and tuber crops and a consequential increase in economies of scale, there would be the need to have machines with increased capacities to meet likely increase harvest requirements.

3.97 These requirements can be achieved through the design of high capacity machines. However, because of lack of technical know-how the small scale manufactures, who are skilful mechanics and craftsmen, are unable to design and make use of drawings to produce high capacity machine since their manufacturing processes are based mostly on copying and imitation of models from their previous apprenticeship and/or employment. These craftsmen, who acquire their skills mostly through apprenticeship to master craftsmen, however, display a remarkable ingenuity in technology adaptation and the substitution of local inputs for imports for their manufacturing operations.

It is important however for these manufacturers to be educated on the use of drawings etc, in the manufacturing process in technical training programmes since product design drawings are important in technology development. Drawings facilitate the ready manufacture of spare parts and the maintenance of machines, and give the customer confidence in his own ability to maintain the machine components.

3.98 Due to the absence of documented drawings and designs, there is lack of standardization in the machines produced by the small enterprises. The non-existence of standardization makes it difficult for these small scalers to produce interchangeable machine componets or spare parts for their products.

Construction materials

3.99 Many food processing machinery manufacturers, including root and tuber crops processing equipment manufacturers, depend on scrap iron as construction materials. In the short term and for small scale manufacturers, this practice may be unavoidable since foreign exchange constraints and the high cost of procurement have caused intermittent shortages of iron and steel leading to the extensive use of local scrap materials as substitutes. The major disadvantage with the use of scrap material is the production of low quality, non-durable corrosive machinery and equipment. The effect of using such machinery for food processing is possible contamination of the final food product which has a deleterious effect on consumers. In fact it compromises the hygienic state of the food product. The dependence on scrap metal in the manufacturing process makes it difficult for manufacturers to adhere to specific design and this results in the production of products of non-uniform standard which creates a problem for certification. The use of scrap metal tends also to determine the modifications necessary to existing designs and makes repairs and maintenance by small scale food processors difficult. In some cases, components of the equipment tend to rust after some time as evidenced in the perforated metal sheet of the grating rotor of cassava graters. This is not good aesthetically and psychologically for a machine which is used frequently to process cassava

into products which are consumed more or less directly.

Cassava Peeler

3.100 Some attempt has also been made in Ghana to develop a mechanical peeler. This has resulted in the development of a revolving welded mesh cylindrical cage into which the tubers are fed. In the course of revolution which is very slow, most of the feathery skin of the tubers is removed. Removal of the feathery skin is however not a solution of the cassava peeling since the feathery skin is an insignificant portion of the peel. To peel the cassava completely is to remove the thick skin of the tuber.

A mechanism consisting of a spring-loaded knife edge which can penetrate the thick skin of the cassava and clutch assembly for engaging and disengaging the knife edge to and from the cassava tuber while gripping and rotating it can undertake "contour" peeling of the cassava. Such a device when developed may be a feasible peeler.

Peeling of the cassava roots by means of chemicals have also been tried. Lye peeling with caustic soda, 5-10% concentration shows that with immersion times of 3-5 minutes and drain times of at least 1 minute the peel was not removed. Higher concentration may remove the peel but this is likely to affect the edible portion of the tuber and consequently affect the fermentation of the cassava mash adversely. Lye peeling also needs the development of equipment to maintain the caustic soda at constant concentrations and suitable temperatures and containers into which the roots can be immersed.

In another attempt to upgrade the peeling operation in cassava processing freshly harvested cassava roots are hand-trimmed to remove the top and tail and are then chopped into 100 mm length segments. About 250-300 kg. are weighed, washed amd fed into a revolving eccentric drum similar to conventional concrete mixer but with abrasive inner linings. As the drum revolves some peeling of the roots is effected through the combined action of the abrasive linings and the rubbing of the roots against one another. Peeling of the roots is assumed complete when the outer corky layer has been removed and incompletely peeled roots are hand-trimmed. Water is continuously pumped into the mechanical peeler and so the peels are washed out.

One obvious handicap of this mechanical peeler is its inability to handle effectively the irregular-shaped roots. There is generally overpeeling especially if prolonged beyond 3 minutes. Together with the hand-trimming, the peeling loss is estimated to be more than 30-40 per cent compared with 25 per cent loss by hand-peeling alone.

Another mechanical peeler which has been developed and reported to be suitable for village use consists of an oval chamber with holes cut along the walls and lined with sharp wire gauze. Cassava roots are loaded into the chamber, which is mounted on two mild-steel rods, 35 cm in diameter, attached at either end. The rods allow the chamber to rotate clockwise. The left rod is connected to a 3.7 kw electric motor by means of a V-belt pulley. Thirty balls coated with wire gauze are added to the chamber. The machine is mounted at a 33 angle in which position the sharp-edged chamber and the balls carry out effective abrasive peeling of the cassava roots during rotation. The roots are cleaned as they are being peeled as the chamber rotates through a water-filled pan mounted below it, the

water passing through the holes into the chamber to wash the roots.

Performance evaluation shows that this mechanical peeler is least efficient when handling unsized roots, hand trimming being necessary. It is also observed that the small roots are peeled before the large ones and they even disappear completely before the large ones are peeled. The efficiency is improved when the samples are sorted by size. On the whole the performance of the machine is observed to be best for medium and large roots. The machine efficiency is also observed to improve when the balls in the machine are of various sizes. Because cutting and sorting of the roots are time-consuming the machine needs to be carefully adjusted to peel at maximum efficiency to offset the time and labour used in manual operations.

Another cassava peeler tried elsewhere is a mechamical stripper-crusher, which splits the cassava root vertically into four long pieces. The disadvantage of this peeler is that considerable loss results from an attempt to peel a non-uniform cassava "quarter", since the skin in the inner part cannot be reached unless certain amount of material has been removed at the thicker portion.

The Cassava Grater

3.101 One root and tuber crops processing machine which is in use in many parts of the country is the cassava grater. There are two main types: the manual or hand held grater and the power-operated grater. Within the power-operated group variations in design, power source, transmission and material of construction occur, especially in the cylindrical or drum type.

3.102 Most of the raspering rotor in both the cylindrical and disc grater consists of a perforated metal sheet nailed to a cylindrical or a disc - shaped wooden block. The abrasive protrudings of the perforations have jagged ends with metal chippings, many of which are loose especially in newly-constructed grating surface. In the course of grating some of the chippings are dislodged and become incorporated in the grating cassava mash. Within about 6 months of regular use the grating surface wears away to such an extent that there is a loss in its effectiveness in size-reduction which often necessitates its replacement with a new one.

The perforated metal sheet is also not standardized in terms of the aperture sizes and number of holes whose abrasive ends constitute the grating surface. There is therefore neither a correlation between the grating surface and the fineness of the particle sizes obtained which greatly influence the quality of the final marketable product such as gari nor is there a correlation between the nature of the grating surface and the rupture of the cassava root cells to liberate starch to produce starch.

3.103 Some cylindrical graters have their grating rotor made of a cylindrical wooden block into which is imbedded longitudinally twelve saw-teeth blades and are therefore able to cause better rupture of the starch cells of the cassava. However, the staggered nature of the teeth on the blade the number of teeth on a blade and the number of blades imbedded in a wooden cylinder for maximum grating effect appear to have been determined arbitrarily.

3.104 In some of the cylindrical graters there is an adjustable saw-tooth blade attached to a wooden board at the lower portion of the grating rotor which aids in the size-reduction of the cassava. In a few models also the adjusting threaded shaft attached to the wooden board is unnecessarily long and may be shortened without any adverse effect on the size-reduction operation.

3.105 There is a pressure application unit for pressing the root and tuber crops against the raspering rotor when in operation. Two designs are being produced for the cylindrical grater: the first one consists of a rectangular wooden block to which is attached a leverage handle, and moves guide rails; the second one is made of a concave dish with a curvature similar to the curvature of the raspering rotor surface and having a leverage handle. These leverage presses need a continous operation by one man.
The first leverage press could be replaced by a loaded spring backed weight which would press the cassava against the rotating grating drum until the cassava is completely grated. The second leverage press could be improved by a loaded spring backed weight as a counterpoise arrangement.

3.106 In all the graters, the grating should be such that it does not wear away so easily. In the cylindrical grater, the grating may consist of a drum composing of a number of hardwood segments covered with aluminium sheeting and having double-edged saw-teeth blades inserted longthwise between each pair of segments. The two open ends of the drum can be covered with a mild steel plate with a central hole for a steel shaft. Saw-teeth blades which become blunt can be reversed to expose the opposite edge for use.

Another consideration for a cylindrical grating rotor could be a hollow steel cylinder with staggered milled surface and with a central shaft welded to cross-bars at the ends which may be covered.

In the case of disc graters, the grating surface could be a steel disc with radially staggered milled surface.

3.107 Diesel-engine powered cylindrical graters use the same 6kw diesel engine as the plate mill (corn mill) under the same roof, the power being transmitted by means of a different flat belt for each machine. Even graters singly installed use similar diesel engines or oversized electric motors, ranging from 7.5 - 11.2 kw. The size of the grating rotor and the torque needed for a grater's efficient operation however requires a less powerful engine or motor and in most cases a 5kw could be ideal as it would result in considerable savings in initial and operating costs. A 6kw diesel engine or motor may however be justified where a corn mill is also installed on the same premises. Since only when either the grater or the corn mill is to be used that it is coupled to the engine or motor and not the two at the same time, the use of a high rating power unit may not be justified. In any case, the use of 7.5-11.2kw power units could only be justified on the premise that they may not be subjected to as frequent heating as the lower rating power supply units.
Reduction in the diameter and weight of the grating rotor could also result in energy cost savings.

3.108 Power transmission from the diesel engine or the electric motor is by means of flat belt and pulley in cylindrical graters and by means of V-belt and pulley in disc graters. In the V-belts the frictional contact between the sides of the belt and the sheave flange of the pulley results in

less slippage and therefore better power transmission than obtains in the flat belts.

The merits and demerits of the choice of power transmission for a given situation need study.

Bearings used in the construction of cassava graters are to hold various power-transmission parts like shafts in position. In most of the cylindrical graters plain or friction bearings in which the shaft is in direct contact with a fixed bearing surface are used causing wearing of the surface in course of time. In the disc graters, anti-friction bearings, in which steel balls or rollers are placed between the shaft and the supporting bearing, are used causing virtually no wear on the supporting bearing surface. In the use of both types of bearings no provision has been made for grease nipples.

In the processing of cassava a lot of water is used. Bearings used in the construction of graters therefore need to be totally enclosed to protect them from splashes of water and they should have grease nipples for lubrication to ensure long, trouble-free service and to prevent possible breakages especially in anti-friction bearings.

The proper bearings to use need to be determined by the amount of wear, the speed at which the shaft is to turn, the load it must carry and the amount of end thrust.

3.109 Various materials such as iron, mild steel, aluminium and wood are used in the construction of the components parts of cassava graters. Some of the materials are however not particularly suitable for certain parts.

Cassava tubers usually contain small amounts of hydrogen cyanide which although disappears in the course of processing imparts a bluish tint to grated mass in the presence of iron. Iron is therefore not a suitable material for components of the grater which come into contact with the cassava mash.
Iron is however good for the framework of the grater such as the stand. Mild steel can be used for the hopper. Where the hopper is made of wood, the inside could be lined with aluminium sheeting. Wooden grating cylinder or drum could also be covered with aluminium sheeting before the perforated metal sheet is clasped around it. Lining or covering wooden components of the grater with aluminium sheeting facilitates the thorough washing of the components and in the case of the wooden cylinder it also prevents juice from grated material seeping into the surface to cause wood rot and generate microbial growth which is likely to contaminate subsequent cassava mash. Aluminium sheeting may be used for the chute and steel used for the construction of the cylindrical and disc grating components since the galvanized sheet in use now gets rusted after some time.

3..110 Some of the cylindrical graters, especially those in the Kaseh market area, are virtually permanently installed on concrete stand-cum-trough which serve as receptable for the cassava mash and from which the mash is scooped into enamel bowls. In course of time the concrete trough surface wears away through the scooping process and any materials so removed are likely to be incorporated into the cassava mash scooped.

Most other graters however have been provided with stands of angle-iron framework and are therefore movable.

Dewatering press

3.111 Various type of cassava mash dewatering presses have been fabricated locally. One of such presses, the parallel board press, consists of parallel boards held apart by two threaded rods with butterfly nuts, in between which (the boards) polypropylene sacks are pressed by screwing. Another press consists of a cage in which the pressing force is generated by a lever and friction ratchet system. Various types of steel frame presses available consists of a wooden cage or basket in which the pressing of the sack loaded with the cassava mash is done. The cage is usually placed in a shallow rectangular or circular metal basin with a chute ,for the passage of the milky liquor.

Another press consists of a steel framework in which a screw spindle welded to a rectangular or circular metal plate is turned to press a polypropylene sack loaded with cassava mash placed in a rectangular or circular metal cage below. The cage, which is welded to angle-iron stand, has a chute for the discharge of the cassava liquor. A modified version of this press has the screw spindle with the attaching metal plate operating within a steel frame housing to press the loaded polypropylene sack. Pressure is applied until about 30 per cent of the mash is pressed out as exudate. The partially dewatered mass is either left in the press to ferment or is removed and put into suitable containers to ferment. The press has a capacity of 32 kg of grated cassava per charge per hour. Unlike the parallel board press, this press and others which have chutes at the base facilitate the collection of the cassava mash exudate for further processing into starch, tapioca and glucose syrup. Additionally,these presses help to maintain the anaerobic conditions desirable for any subsequent fermentation process such as in agbelima and gari making.

An hydraulic press is also being locally produced but its acceptance is very limited due probably to its high cost.

Gari roaster

3.111 Traditional gari roasting equipment which causes a great deal of discomfort to women processors has been discussed in earlier chapters under gari production technology.

3.112 An upgraded roasting unit which reduces the discomfort and improves on the energy consumption per unit output of gari has been produced but it is in limited use. This unit consists of a hearth of cement blocks laid out in a rectangular fashion with the top and front ends open. A chimney with cowl attached to the closed rear end allows smoke from the fireplace to exhaust. A shallow roasting cast-iron pan is placed on top of the blocks. The enclosure mapped out by the pan and the blocks serves as a fireplace for fuelwood. Some of the roasting units are too large and cause uneven distribution of heat and difficulty in stirring.

3.112 A mechanical gari roaster has also being produced but so far its use has been very limited. This roaster consists of a lower horizontal half-cylinder (cut longitinally) topped with an upper rectangular section. The lower half cylinder and one-half of the upper rectangular section are made of stainless steel. The steel portion is heated by a suitable fire place below the bottom which is 120cm long and 70cm in diameter. The uppermost rectangular section which is made of wood and is 25cm deep is not subjected to direct heating from the fireplace. A longitudinal stirrer made of four metal bars welded on to a pair of spoked wheels at the end of the bars which is within the steel portion of the roaster and is attached to

a longitudinal shaft which is driven through a set of pulleys by a diesel engine. The roaster has a sturdy angle iron support. The use of the roaster has not been promoted because initial trials have not been too satisfactory due to likely flaws in its design.

To improve the efficiency of this mechanical roaster, the paddles of the stirrer could be made of wood and be spring-loaded to enable them tranverse the curvature of the horizontal half-cylinder sweeping the roasting material in suitable residence time dictated by the rpm of the stirrer. The rpm which should be very low about 20, could be obtained by means of reduction gears from a 1400rpm of a 7.5 - 11.2kw electric motor or diesel engine. The half-cylinder could be accommodated in a clay housing insulation to conserve heat needed for the roasting operation and be served by a gas stove made of perforated metal tubing. The whole set-up should be inclined at a small angle to a conveyor or a bag filling container into which the gari can fall. Pilot scale model's of the suggested equipment would need tests to assure its performance.

The roasting operation in gari production involves two phases: a mass transfer phase and a heat transfer phase. Gelatinization of the gari occurs during the mass transfer phase, whilst complete dehydration is achieved during the heat transfer phase. The purpose of the roasting operation is essentially to achieve a mass transfer resulting in gelatinization and a granular structure of the gari and therefore temperature at this phase is low. The temperature is however high in the drying stage. Development of mechanical roasting equipment should therefore consider how the two phases of mass and heat transfers can be incorporated in a machine to achieve the desired results.

Various types of roasting equipment consisting of two smokeless stoves on which cast-iron pans are mounted are also in production. Heat energy for these stoves are provided from a common fire place served with fuelwood. Construction materials for the stoves are burnt clay bricks. In some instances the roasting pans are too large for even heat distribution throughout the length and breadth of the equipment, and this results in inefficient roasting performance.

Spare parts and repairs

3.113 Of the many components of the cassava grater one which has a very short useful life is the perforated metal sheet which constitutes the grating surface. Spares for the replacement of this component are made from scrap metal by a number of small scale roadside cassava grater manufacturers mostly in Nsawam, Eastern Region. Distribution and marketing of the spare parts are however limited to the manufacturers' workshops.

3.114 Many manufacturers also undertake the repairs of the complete assembly of the grating rotor, namely the perforated metal sheet and the wooden cylindrical block on which it is nailed the shaft and the block bearings.

Managerial Skill

3.115 Most of the operators in the small scale cassava processing equipment manufacturing enterprise have limited managerial capabilities, which are not matched with their rather high enterpreneurial initiatives. These entrepreneurs have very little formal education, at best they may have basic education. As operators, they might have got their ideas or skills from their previous employment and trade where

they were either employees of enterprises producing the product or they were themselves distributors of the product. In many cases the managerial problem has limited their scope of operations. In certain situations managerial incompetence has led to operational inefficiencies resulting in poor performance.

Capital

3.116 Most of the operators in the food processing machinery sector started their enterprises with their own capital and assistance from relatives and friends. An additional source of finance is the "SUSU" (Credit Union) where members are granted loans to finance their business.

3.117 The "SUSU" system of saving has two versions: rotating savings through "SUSU" clubs and individual "SUSU" collectors who operate a deposit facility for any number of people. The typical susu club consists of members who agree to make regular contributions to a fund which is given in whole or in part, to each contributor in rotation.

3.118 The individual collector (usually a male) visits shops, workplaces, market stalls and homes (usually on bicycle) at agreed times each day and collects a specific amount determined by the saver in consultation with the collector. After an agreed period of time - usually on the last day of each month - the deposits are returned, less a day's deposit as commission.

3.119 Most of the businesses in the sector are not formally registered as statutory entities and therefore do not pay taxes. Their operators are therefore afraid to approach financial institutions for loans. The sector on the whole, has however been starved of institutional credit. The

demand for physical collateral and high interest rates of up to 30 per cent, which operators cannot meet, have made it difficult for them to have access to credit.

Marketing

3.120 The manufacturers of food processing equipment produce largely for the domestic market, although a few have ventured into exporting some of their products to neighbouring countries. Where these manufacturers produce on order marketing has not been a constraint. But generally, marketing of these products has been a problem due mainly to their lack of marketing techniques.

Barns

3.121 The design and construction of yam storage barns vary widely in the country and there is therefore the need to standardize them, in terms not only of construction materials but also in terms of sizes and capacities. This would allow the determination of bill of materials and their specifications for the different capacities.

H.4. Assessment of the Suitability of Improved Cassava Varieties to Local Processing Methods.

3.122 A varietal release sub-committee of the National Committee on Root and Tuber Crops Development in Ghana (NCRTCDG) has assessed four improved varieties of cassava which were introduced in Ghana in 1988, namely TMS 30572 (GC88-07), TMS 50395 (GC 88-05), TMS 4(2)1425 (GC88-03), and TMS 91934 (GC88-02). The criteria used for the assessement are in Appendix...7.....

3.123 The main findings and conclusions of the assessment are:

1. TMS 30572 (GC88-07)

This variety originally from IITA was introduced to Ghana in 1988 under a new code name GC88-07. The easily identifiable morphological characteristics are:

Light green petiole, brownish grey mature stem and light brown outer-skin of root with creamy inner skin.

It fits into our farming systems because it can be grown as a sole crop or intercropped with most of the local field crops and can also be grown in both major and minor seasons. It is highly tolerant to major pests and diseases and is also suitable for making gari, agbelima, and kokonte but not good for fufu or ampesi. Yield and HCN contents are tabulated as follows:

(a) Average Yield (tons/ha)

- On station fresh roots.... 30.0 (5-7 locations for 3 yrs)
- On station dry roots .... 9.0 (Dry matter (DM) % = 30)
- On farm fresh roots .... 27.5 (Av. over 30-50 farms in 5 main agroecological zones for 2 yrs.)
- On farm dry roots 8.25

(b) HCN Content (mg/100g)

Unpeeled fresh root	....	13.00 - 25.5
Peeled fresh root	....	15.25
Ampesi	....	3.24
Fufu	....	N.D
Kokonte	....	8.20
Agbelima	....	2.72
Gari	....	1.05 - 5.20

2. TMS 50395 (GC 88 - 05)

Also introduced to Ghana from IITA and coded GC/88 - 05. Major identifiable morphorlogical characteristics are: Light green petiole colour with purplish tip, brownish grey matured stem, dark brown outer skin colour of roots and cream inner skin colour.

This variety is suitable for intercropping with most of the local field crops grown in Ghana. It can also be grown as sole crop. It can be planted in both major and minor seasons. It has medium to high tolerance to major pests and diseases. It is suitable for the preparation of Gari, Agbelima and Kokonte but not for fufu and ampesi.

Yield and HCN content are tabulated below

(a) Yield (tons/ha)

On station fresh roots ..... 38.80 (5-7 locations for 3 years)

ON station dry roots ..... 10.55 (Dry matter (DM) % = 27.2)

On farm fresh roots ..... 32.6 (Av. over 30-50 farms in 5 agroecological zones).

On farm dry roots 8.87

(b) HCN Content (mg/100g)

Unpeeled fresh root	....	19.75 - 23.78
Peeled fresh roots	....	18.75
Ampesi	....	6.64
Fufu	....	4.16
Agbelima	....	2.08
Kokonte	....	4.24
Gari	....	0.52 - 2.01

3. TMS 4(2)1425 (GC 88 - 03)

Also originally from IITA and introduced to Ghana in 1988 under the code name GC 88 - 03. This variety can be identified by the following morphological characteristics: It has yellow petiole with pinkish tint, brownish white matured stem, brownish white outer skin of root and cream inner skin colour of the root.

This variety may be grown sole or intercropped in both the major and minor seasons. It is moderately tolerant to the African Cassava Mosaic Virus Disease (ACMVD) and highly tolerant to other major cassava diseases and pests. This variety has very high consummer preference due to its suitability for

the preparation of all the important food items, Ampesi, Fufu, Gari, Agbelima and Kokonte.

Yield and HCN content are tabulated below.

(a) Yield (tons/ha)

On station fresh roots	....	31.2 (Av. over 5 - 7 locations in 3 years)
On station dry roots	....	9.48 (Dry matter (DM) % 30.4
On farm fresh roots	....	26.00 (Av. over 30 - 50 farms in 5 main agroecological zones for 2 years.
On farm dry roots	....	7.90

(b) HCN content (mg/100g)

Unpeeled fresh root	.....	8.35 - 240
Peeled fresh root	.....	17.50
Ampesi	.....	4.64
Fufu	.....	2.10
Agbelima	.....	3.84
Kokonte	.....	3.52
Gari	.....	0.42 - 2.28

4. TMS 91934 (GC 88 - 02)

Originally introduce from IITA in 1988 and given the code name GC 88 - 02 this variety is identified by its yellow petioles and light brown matured stem. The outer skin colour of the roots is dark brown while the inner skin is cream in colour.

Due to its architectural form and bunchy roots TMS 91934 is well suited for intercropping and mechanical harvesting. It can successfully grow in both major and minor seasons as sole or in mixtures with other field crops. Apart from ACMVD to which this variety can be highly susceptible it is moderately to highly tolerant to other major pests and diseases. The roots are suitable for processing into gari, agbelima, and kokonte but not for preparing fufu or ampesi.

Below are data on root yield and HCN content

(a) Yield (tons/ha)

On station fresh roots	.....	28.0 (Av. of 5 - 7 locations for 3 years.
On station dry roots	.....	7.28 (Dry matter (DM) %) 26.0
On farm fresh roots	.....	20.00 (Av. over 30 - 50 farms in 5 main agroecological zones)
On farm dry roots	.....	5.20

(b) HCN content (mg/100g)

Unpeeled fresh root	.....	15.4 - 24.8
Peeled fresh root	.....	23.25
Ampesi	.....	6.48
Fufu	.....	2.96
Kokonte	.....	8.16
Agbelima	.....	2.16
Gari	.....	2.10

5. Ankra (Local Variety used as control)

Important' morphological characteristics used for identification are:
Pink petiole, matured stem colour is brown outer skin of roots and pink inner skin colour.
It is adapted to all ecological zones of Ghana and grown in both major and minor seasons as sole or intercrop. It has low tolerance to ACMVD. This variety is an all purpose cassava suitable for preparation of all major food forms prepared from cassava.

Yield and HCN content are as below

(a) Yield (tons/ha)

On station fresh roots	....	16.03 (Av. of 5 - 7 locations for 3 years.)
On station dry roots	....	5.84 (Dry matter (DM) %) 36.5
On farm fresh roots	....	17.0
On farm dry roots	....	6.21

(b) HCN content (mg/100g)

Unpeeled fresh root	.....	4.55 - 23.9
Peeled fresh root	.....	7.0
Ampesi	.....	1.1 - 2.8
Fufu	.....	2.08
Kokonte	.....	2.81
Agbelima	.....	3.21
Gari	.....	0.53 - 1.04

6. Field Trip

One field trip was made by the members of the sub-committee to verify some of the data presented by the researchers. At the field life plants were observed, morphological characteristics of the varieties were noted. Harvested roots were observed and cooked roots tasted. These invariably confirmed data presented.

IV. RECOMMENDATIONS

Funding

4.01 Root and tuber crops provide the bulk of Ghana basic staple food requirements yet they receive insignificant funds for production and research. To be able to continue to maintain their traditional role and enhance their assistance in national food security the government through the Ministry of Food and Agriculture (MOFA) should allocate adequate funds to rehabilitate, upgrade and develop the root and tuber processing and preservation subsector of the agricultural sector of the economy. For this some form of external funding assistance to the Government of Ghana (GOG) should be considered.

Cassava Processing and Preservation

- Register of processors

4.02 A compendium of cassava processing units should be compiled by extension and post-harvest development officers of MOFA in collaboration with the staff of District Assemblies. To facilitate such compilation, the District Assemblies in co-operation with MOFA should encourage the formation of a National Cassava Processors Association. Such an association would facilitate considerably the provision of financial and technical assistance to its members and would assist in generating income through tolls or taxation for the District Assemblies.

Storage and availability

4.03 Within the framework of Ghana's Medium Term Agricultural Development Programme MTADP and the envisaged increase in agricultural production overall, storage techniques for extending the keepability of cassava roots to make them available at remunerative prices all year round should be vigorously promoted in village communities. Such promotion exercise would make the cassava roots readily available to processing plants and would help increase processing plants capacity utilization efficiency.
The promotion exercise should be initiated by the SRDP in collaboration with MOFA and the National Agricultural Research Programme (NARP) and should involve the Post-Harvest Development Unit of the Crops Services Department, the Extension Services Department both of MOFA, the Food Research Institute (FRI) and the Crops Research Institute (CRI) both of the Council for Scientific and Industrial Research (CSIR).

A proposed methodology for this cassava storage technology transfer is in Annex 8.

Water supply

4.04 Potable water is a vital requirement in cassava processing and therefore every effort should be made by SRDP through MOFA and in co-operation with Ghana Water and Sewerage Corporation (GWSC) and the Water Resources Research Institute (WRRI) of the CSIR to provide boreholes in suitable locations for use by cassava processors within a given geographical area.

For such undertaking some form of external funding assistance to GOG could be sought.
In cassava processing units where river water is used for processing, MOFA extension staff and/or GWSC should be equipped to monitor on regular basis the bacteriological quality and potability of such waters.

Power supply, unit

4.05 Although the initial cost of diesel engine as the prime motive power for cassava processing machines is high the operating cost may be low and it does not depend on external source to generate power.

In the village communities the use of diesel engine 4 - 6kw rating for operating cassava processing plants is recommended.

Gari production technology

- Peeling

4.06 Peeling of cassava roots constitutes a bottleneck operation in the processing of cassava into gari and other products. Mechanical methods of peeling so far tried give low peel removal and require extensive manual trimming.

The design and development of a cassava peeler would facilitate small scale processing of the roots and help upgrade cassava processing overall and relieve rural women processors of a tedious job.

Institutions such as the Food Research Institute (FRI), the Industrial Research Institute (IRI) both of the Council for Scientific and Industrial Research (CSIR), the Agricultural Engineering Department and the Mechanical Engineering Departments both of the UST and the Mechanical Engineering Departments of the Polytechnics should be encouraged by SDRP to design and develop a cassava peeler.

- **Washing**

4.07 In cassava processing units, especially where gari is processed suitable washing troughs made of cement blocks and lined, both inside and outside, with white wall tiles should be constructed by the cassava processing plant funding institutions for the washing of peeled cassava roots, processing utensils and sacks used in the dewatering and fermenting operation. The troughs should have water drain outlet to let out wash water.

- **Grating**

4.08 The Smallholder Rehabilitation and Development Programme (SRDP) should promote the use of power-operated cassava graters in village communities where cassava is processed into gari especially in the Northern Region. This should be done through SRDP financial credit scheme.

Dewatering

4.09 The design of equipment used in the dewatering operation should be standardized and their capacities increased so that they can be synchronized with the capacities of other machines in the process of gari manufacture. This assignment should be undertaken by the manufacturers themselves and in collaboration with FRI, IRI and the Agricultural Engineering Department (AED) of UST.

- **Fermentation**

4.10 The fermentation of cassava in the production of gari and agbelima needs to be shortened by seeding freshly grated mash with a standardized innoculum made from either fermented cassava juice or fermented and dried cassava pieces.

The FRI and the Department of Nutrition and Food Science (DNFS) of the University of Ghana (UG) should be asked to investigate the preparation of the different types of innocula and to standardize their methods of preparation. With this done, SRDP in collaboration with government and non-governmental agencies, should then encourage and promote the use of these standardized starter cultures in cassava fermentation.

- **Sifting**

4.11 The bamboo sieve used in the sifting operation has proved its worth. For durability and ease of cleaning and sanitizing after use, an aluminium sieve with the same aperture size could be introduced gradually alongside the bamboo one by SRDP and other agencies.

- **Roasting**

4.12 In order to reduce the excessive woodfuel waste and high energy consumption and the undue human discomfort and sickness arising from the roasting operation in gari production the SRDP should promote the use of woodfuel smokeless stoves in collaboration with the Department of Rural Housing and Cottage Industries (DRHCI).

4.13 In order to reduce the excessive reliance on woodfuel for roasting with its attendant environmental degradation, the SRDP should encourage and promote the use of biogas and Liquified Petroleum Gas (LPG) with its accompanying stoves, in the cassava processing industry. The promotion exercise should be done in collaboration with the Ministry of Energy (MOE), the Ghana National Petroleum Corporation (GNPC) and the 31st December Womens' Movement (31 DWM).

4.14 The SRDP should in collaboration with the 31 DWM, the FRI and MOE introduce and promote the use of improved roasting stoves with chimneys and which use woodfuel, biogas and LPG to village cassava processors.

- **Packaging**

4.15 In the villages gari is bulk packaged, stored and distributed in jute fibre sacks or polypropylene sacks. For retailing gari is displayed and sold in open-top enamel and aluminium basins at market places or are packaged in low density unlabelled polyethylene pouches.
It is recommended that for bulk packaging the jute sacks should be lined with medium density polyethylene film if possible, to prevent possible wetting during distribution and marketing and the pick-up of odour from the jute sack when in storage.

4.16 For retailing, the gauge of the polythylene film used for packaging should be at least 5 mil. to prevent bursting. For retailing in supermarkets, the gari should also be packaged 5 mil. gauge polyethylene pouches with proper labels which give information on description of the article, the weight, trade mark or name of manufacturer, instructions for uses and dates of manufacture and expiration.

The Food Research Institute (FRI), and National Commission on Women and Development (NCWD) and the Ghana Export Promotion Council (GEPC) apart from producers should be requested to design and promote proper packaging in gari distribution and marketing.

Agbelima Production Technology

4.17 Studies should be conducted into agbelima production especially with regard to fermentation, storage and sale since it is known that foods prepared from some agbelima have resulted in food poisoning of consumers, The FRI and the Department of Nutrition and Food Science (DNFS) University of Ghana should be requested by SRDP to undertake such studies. These studies could be done jointly with the gari fermentation study in 4.10.

4.18 The SRDP in collaboration with the NCWD, and District Assemblies (DA) should mount a campaign to educate processors and dealers in agbelima on the need to maintain sanitation and hygiene in the production handling and sale of the product. Audiovisual aids depicting more suitable and alternative ways of handling and distribution of agbelima should be produced and used in the campaign.

Kokonte Production Technology

4.19 The SRDP in collabroation with MOFA should map out a strategy for the fumigation of stored kokonte with suitable chemicals after 4-5 months storage in the barn or room to reduce and/or prevent insect infestation. Toxicity levels of the chemical treatment should be such as to prevent food poisoning.The fumigation exercise should be organised in large scale kokonte producing villages in the northern parts of Brong-Ahafo and Northern Regions with the active participation of surrounding small-scale kokonte producing villages.

4.20 Alternatively the SRDP could commission a very short term study of 1-2 person - months duration into the infestation and damage caused by pests to kokonte in storage and make recommendations on suitable methods of control.

On the basis of the study, SRDP in collaboration with MOFA should organize demonstration and training exercises in the prevention of pests of kokonte in storage. The exercises should be carried out mostly in large-scale kokonte producing villages in the northern parts of Brong-Ahafo and Northern Regions with the active participation of surrounding small-scale kokonte producing villages.

4.21 The improved crib for drying and storing maize should be introduced and promoted for kokonte storage. The Post-Harvest Development (PHDU) of the Crop Services Department (CSD) and the Extension Service Department (ESD) both of MOFA have jointly initiated modest introduction exercises in this direction in very few villages in the Northern Region. The Small holder Rehabilitation and Development Programme (SRDP) should encourage these efforts and assist

in the introduction and promotion of the improved kokonte storage technique on a much wider scale and coverage. To help the SRDP in this regard two methods for building the improved crib are attached for easy reference as Annex 9.

4.22 The Smallholder Rehabilitation and Development Programme (SRDP) should initiate concrete action to improve the traditional cylindrical round barn for kokonte storage. The improvement exercise should involve the raising of the base of the barn one metre above ground to prevent wetting from ground moisture and theft from sheep and goats, using rat guards on the legs to prevent rodent attack and using additional strong sticks to strengthen the framework and the base. Demonstration of the construction of the improved barn should be done initially at few selected villages with full participation of some inhabitants of nearby villages. For this work SRDP should enlist the collaboration of PHU and ESD of MOFA.

4.23 Alternatively the SRDP could commission a very short-term study of 1-2 person months duration, into the quantity and strength of materials of construction, the loading capacities, the sizes etc. of the various kokonte storage barns and rooms and the elevated drying platforms especially in the northern parts of Brong Ahafo and Northern Regions and make recommendations for their improvement.

Capacity utilization

4.24 There is generally low capacity utilization in most cassava processing units especially the NGO-funded institution owned ones.
To increase the level of capacity utilization, the plants

should be sited in locations which will enhance and facilitate customer participation.

4.25 In high potential cassava growing areas NGO-funded plants should not be sited too close to one another; one plant should be sited at least 6-8km from the next plant so as to allow each plant to attract the greatest number of customers.

4.26 Non-governmental organization (NGO) funded institution-owned cassava processing plants should establish cassava farms to supplement their raw materials requirements for gari production so as to raise their capacity utilization levels.

4.27 Processing procedures for gari especially in NGO-funded plants are quite slack resulting in time wastage. It is recommended that gari production procedure regimes, with working periods of 10 hour-day, 6 day-week, be established by each NGO-funded cassava processing plant which should be properly supervised for increased productivity.

Mobile cassava grating units

4.28 In order to generate more income and also assist in village processing and subsequent rural industrialization, District Assemblies (DA) in high potential cassava growing areas, should establish and operate mobile cassava processing units to undertake cassava grating and dewatering services on custom hiring basis in remote villages within their areas of jurisdiction.

A processing unit should consist of either a grater with a self-starting motor as the motive power unit or/a grater operated from the power-take-off (p.t.o.) of a tractor on which it should be mounted plus a screw press.

For mounting and transporting the grater and press in rural areas the high clearance wide wheelbase Tinkabi tractor manufactured in Swaziland is recommended.
The particulars of the Tinkabi tractors are given in Annex 10.
The mobile service units could be operated in co-operation with NGOs or private individuals or institutions.

Cassava Drying Units

4.29 Drying units for producing cassava chips for export should be set up on co-operative basis in selected high potential cassava growing villages. Each unit should have a diesel-powered mobile high pressure fan or blower for blowing hot air through the raw cassava chips loaded in a rectangular bin to dry the chips similar to the equipment in Annex 11

SRDP should collaborate with the FRI, PHDU of MOFA, District Assemblies and the Export Promotion Council in these ventures.

4.30 In villages where large quantities of kokonte are produced by sun drying during the harmattan season, the drying units should be used as supplementary dryers to accelerate drying and reduce or prevent fermentation of the cassava chips in order to enhance their export marketable quality.

4.31 In villages where large quantities of kokonte are produced but which are not likely to benefit from the drying units the producers should be taught and encouraged to produce good quality cassava chips for export by size - reducing the cassava pieces dried for kokonte to accelerate drying and by drying the pieces on raised platforms made of

sticks and sorghum stalks on patio made of concrete floors and in solar dryers made up of sawn timber, bamboo or sticks and covered with plastic sheet.

Cassava Starch

4.32 There is no cassava starch manufacturing industry in Ghana and therefore 1500 tons of starch are imported annually for use by several industries. Starch is used for the manufacture of glucose and dextrose. Dextrose is used in food industries and in the textile, printing, laundry, and paper industries.

In order to reduce or eliminate starch imports, create employment opportunities, catalyse increased cassava production and service the aforementioned industries operating in Ghana, a starch manufacturing industry should be established in a strategically suitable area served by very large hectares of high-yielding cassava farms, abundant water supply and electricity.

The SRDP in consultation with MOFA and the Ministry of Trade and Industry (MOTI) should initiate action in this direction.
The technology for the cassava starch manufacture which is fairly simple and can be developed in Ghana is in Annex 12

The SRDP should on its own encourage cassava processing plants to also produce starch on commercial basis. The technology which is very simple involves grating the peeled cassava, squeezing out the starch granules which are allowed to settle in water, decanting the water and sun drying the starch.

Tapioca

4.33 The SRDP should also encourage the production of tapioca from starch by some of the village level starch producing cassava processing plants.

Fufu flours

4.34 The SRDP in collaboration with FRI and other institutions should encourage and promote the production of instant flours from cassava and other root and tuber crops for making fufu.

By-products utilization

4.35 Apart from sundrying of the peels for animal feed, the fresh cassava peels can be used as a substrate for the cultivation of mushrooms. In collaboration with FRI, SRDP should introduce the use of fresh cassava peels in producing mushrooms as a high vegetable protein source and supplement in the diets of rural communities.

4.36 A lot of milky juice is produced as a by-product in the dewatering operation in cassava processing and this is usually allowed to go waste. It is recommended that this milky juice is collected, and decanted to obtain starch. With the assistance of the FRI, this starch could be modified to make glucose.

4.37 In the manufacture of gari in the villages agglomerates of large particles of partially gelatinized gari are produced as by-product. It is recommended that this by-product should be sun dried and sold as feed for livestock to generate additional income for gari producers.

Human resource development

4.38 Training in cassava processing and preservation for village level cassava products' manufacturers with a view to improving upon their operations and the quality of their products should be initiated by SRDP and organized by the FRI.

Two types of training courses should be organized. The first course should be for the training of trainers from all cassava producing regions and should be held at the FRI Cassava Processing Demonstration Unit, Pokuasi, the second course should be mounted at strategic village level cassava prosessing/preservation units locations in the regions using the trainers in the first course as resource persons to train a greater number of people.

4.39 In collaboration with the National Board for Small Scale Industries (NBSSI) and other institutions SRDP should initiate action in the training of village-level cassava processors in entrepreneurship development.

Demonstration units

4.40 In order to conduct and sustain regular training of cassava processors in processing and managerial techniques, and to train a greater number of people at reduced costs, each cassava growing region should establish a cassava processing and preservation demonstration and personnel training centre. The centre should have improved machinery for demonstration and training and should involve scientific and technical personnel as resource persons during training sessions.

Where such a centre cannot be established due to financial constraints, then an existing processing unit could be designated as a training centre for the region. Such a centre should be strengthened with improved machinery and qualified personnel as resource persons.

Yam Processing and Preservation

Curing

4.41 It is recommended that yams meant for storage after harvesting should be cured before storage so that the skins can be toughened and wounds inflicted on the tubers during harvesting and subsequent transportation and handling can be healed.

Curing should be carried out by stacking the tubers in lightly shaded area, covering with dry grass or mat and finally covering with canvas tarpaulin which should not touch the tubers. This results in the tubers being maintained at high temperature between 32-40°C and high humidities of 70-95% through self-generation of heat and moisture. The stack should be kept for 4-7 days.

General principles in yam storage

4.42 There are many types of traditional yam storage structure but the type required for an area depends on the environment. The following general principles should therefore be observed.

When building the structure;

- there should be adequate shade to prevent dessication.
- there should be good ventilation to improve storage and therefore the structure should be in a good position

facing windward side to allow air to circulate freely;
- security against pest and predators should be provided;

Before the yams are put into storage the following principles should be followed:
- sanitation of the storage needs to be undertaken;
- sound tubers ie. wound-free, rot-free, and sprout-free should be selected.

During the period of storage there should be:
- regular inspection to remove rotting and insect-infested tubers;
- rapid disposal of spoiling tubers;
- continued sanitation.

Technical study on the traditional yam barn or crib

4.43 The traditional barn or the crib used in the storage of yams. vary considerably in details of design and construction and there is very little known about the optimum temperature and relative humidity of the barn or crib for obtaining optimum storage life. It is therefore recommended that technical studies into these areas be carried out with a view to developing an improved barn or crib. The MOFA should task the FRI, the CRI and the proposed Root and Tuber Crops Development Board (RTCDB) with the these studies.

Improved storage crib

4.44 The improved crib used for the storage of maize should be modified for the storage of yams. The modification should entail increasing the opening area of the walls for increased ventilation and facilitation of loading and arrangement of the tubers in the crib. Details of

construction of the improved storage maize crib is in Annex 9. with a modified version for potatoes in drawing No.10 of Annex 9.

The modified improved storage crib should be constructed at some high potential yam growing villages for demonstration and training in construction purposes.The PHDU and the ESD of MOFA and the FRI and CRI of the CSIR should be involved in the modification and extension exercises.

Transportation of yams

4.45 Considerable damage is caused to yams during transportation from producing/purchasing centres to marketing centres.To reduce or prevent such damage,layers of yams should be separated from each other with dry grass or any other cushioning material.The ESD and the PHDU of MOFA should be tasked with the demonstration of such cushioning techniques

Yam fufu flour

4.46 The SRDP in collaboration with FRI and other institutions should encourage and promote the production of instant (pre-gelatinized) flours from yam and other root and tuber crops for making fufu.(Vide 4.34 also)

Yam processing factory

4.47 The SRDP,MOFA MOTI and the Northern Regional Administration acting in concert should initiate plans to establish a yam processing factory in either Salaga,Yendi,Bimbilla or Tamale in collaboration with the respective District Administrations. The technology in yam processing is simple and is shown in a flow diagram for the production of pre-gelatinized (instant) yam flour/flakes in Annex 13

Wasawasa production improvement

4.48 The technique used in the production of wasawasa should be improved and standardized so that it can be produced and marketed in a more hygienic and acceptable way. The Home Science Department of the University of Ghana (UG) and the Women In Agricultural Development (WIAD), ESD of MOFA should be tasked with such improvement assignment.

Processing plant establishment

4.49 Many gari producers are found in some villages on the Buipe-Damongo Road and in Damongo District and its environs in the Northern Region. SRDP should through its credit scheme, establish at least three cassava processing plants in these areas. The estimated cost of each such plant is given in Annex 14.

Root and Tuber Crops Development Board

4.50 The Government of Ghana (GOG) through the Ministry of Food and Agriculture (MOFA) should establish a Root and Tuber Crops Development Board composed of government officials, research scientists and technologists, farmers' representative, processors and exporters.

The terms of reference of the Board should be, inter alia:

- increased production of root and tuber crops, on a national scale.
- recommendation of improved varieties for production and processing;
- promotion of the commercial processing and preservation of all root and tuber crops;
- encouragement and promotion of the use of suitable equipment and facilities for processing and preservation.

- improvement in the marketing systems of the raw root and tuber crops and of their processed products and by-products, locally and abroad;
- promotion of research and development in the production, processing, preservation and marketing of root and tuber crops and their processed products;
- enhancement and promotion of the role of root and tuber crops in the food security system of the country.

Cocoyam processing and preservation

Research and development

4.51 There is very little research and development work in cocoyam production, processing, preservation and utilization in Ghana as compared to other root and tuber crops except frafra potato. The SRDP through the MOFA or the proposed Root and Tuber Crops Development Board should encourage and promote a well-planned research and development studies in the above areas in collaboration with the CRI and FRI of the CSIR and the Faculties of Agriculture in the various Universities in the country.

Cocoyam flours

4.52 The SRDP in collaboration with FRI and other institutions should encourage and promote the production of flours from cocoyam for making porridge and fufu (Vide 4.34 and 4.46 also).

Traditional storage improvement

4.53 The traditional storage methods of leaving the roots in the soil, storing in dug-out pits and covering with plantain leaves after harvesting should be upgraded by adopting and adapting the improved storage techniques recommended for cassava storage in Annex .8..... for cocoyam storage. The SRDP through the MOFA or through the Root and Tuber Crops Development Board (RTCDB) should encourage and promote such storage techniques for cocoyam by requesting the FRI and CRI of the CSIR and the Faculties of Agriculture of the Universities to conduct the initial storage trials.

Sweet Potato processing and preservation

Processing

4.54 Apart from the traditional preparation of sweet potato into various snacks, there is virtually no elaborate commercial processing of the crop. Experimental processing of the sweet potato which have eventuated into the compilation of recipes has been conducted by the Home Science Department (HSD) of the Faculty of Agriculture, University of Ghana and the Women In Agriculture Development (WIAD) Extension Services Department, MOFA, Upper East Region. The SRDP should encourage and strengthen the efforts of these institutions so as to have some of the processing techniques translated into commercial ventures.

Sweet potato flour

4.55 The SRDP should encourage and promote the production of sweet potato flour by the FRI, HSD of UG and WIAD of MOFA.

Sweet potato storage

4.56 To upgrade the traditional storage practices for sweet potato, the modified version of the improved maize crib in Drawing 140 10 Annex..9..... should be adapted for sweet potato storage. The adapted crib should be constructed in some high sweet potato growing areas in the Central, Northern, Upper East and Upper West Regions of the country for demonstration and training in construction purposes. The PHDU and the ESD of MOFA, and the FRI and CRI of the CSIR should be requested by SRDP to undertake these adaptation and extension exercise.

Frafra potato processing and preservation
Research and development

4.57 Knowledge on the production, processing and preservation of the frafra potato is scanty because these activities are limited mostly to the Upper East Region of Ghana where it is grown in small quantities mainly for home consumption and there is also virtually little or no documented literature on the crop.
Research and development studies should be conducted to improve and upgrade the traditional technologies involved in the production, processing and preservation of the frafra potato so as to raise them to commercial scale activities. For these studies the CRI, FRI, MOFA and the Faculties of Agriculture of the Universities should be involved.

Locally-produced Small Scale Equipment
and their manufacture

4.58 An analysis of locally-produced equipment shows that indigeneous technology exists for their design and manufacturer. However, improvements are needed in some specific areas.

Workshops and facilities

4.59 There is lack of well-organized plant layout in most workshops. With the need to produce higher number of processing units of better quality serious efforts should be made to improve plant layout so as to increase plant operation efficiency.
The MOST and MOTI acting in concert should request the Accra Technical Training Centre (ATTC) National Vocational Training Institute (NVTI) and Ghana Regional Appropriate Technology Industrial Service (GRATIS) to produce a standard plant

Design

4.60 The FRI, IRI, AED of UST and the various technical institutes should be mandated by MOST and MOFA to test the various root and tuber crops processing and preservation equipment with a view to making modifications which would eventuate in increased efficiency.
For the graters modifications which should be considered include the following:

1. replacement of the levered press by a loaded spring backed weight;
2. replacement of the perforated metal sheet and wooden block and the shaft which together constitute the raspering or grating rotor by either a milled surface solid or hollow cylinder with a shaft for the drum grater and milled surface disc for the disk grater.

For the presses, modifications should address reduction in human effort or energy exertion and the collection of liquid exudate for further processing.

For the roasters, improved designs should aim at reducing discomfort, drudgery, energy consumption per unit of output and the use of Liquified Petroleum Gas (LPG) to reduce excessive reliance on woodfuel.

Production of spare parts

4.61 Manufacturers of root and tuber crops processing equipment should be requested by MOTI to produce spare parts for their machines and these should be availabe in designated shops for purchase.

Drawings of machines

4.62 Manufacturers of root and tuber crops processing and preservation equipment should, on their own, make drawings of the machines they produce or be assisted by local technical institutions to make the drawings for future duplication and/or standardization of the machines so as to facilitate their commercialization and the production of spare parts for their repair and maintenance.

Standardization of materials and machines

4.63 There is generally no standardization in the use of materials and tools in the production of locally-produced equipment and consequently product specification is rough and does not allow for inter-changeability of parts.
There is also lack of standardization of the equipment which are produced. Food manufacturing practices imply that equipment used should be made of good materials which would not impart contaminants to the food product in contact with the processing equipment.
The Ghana Standards Board (GSB) should formulate minimum standards for the quality of raw construction materials, and products standard dimensions and sizes based on the International Standards Organization (ISO) specifications not only for the root and tuber crops processing equipment but also for the whole small scale informal sector of equipment manufacturers. The establishment of standard specifications for small scale producers of food processing equipment would help not only in the manufacture of components and spare parts and create a spare parts industry for the sector but also help to produce items comparable to foreign machines.

Human resource development in equipment manufacture

4.64 Technical and managerial skills are lacking among manufacturers of root and tuber crops processing equipment as only a few possess the requisite expertise in their respective fields. To be able to produce good quality products comparable to international standards, upgrading of technical know-how and managerial skills is needed to expand the scope and increase the efficiency of production of their machines. In this regard the MOTI and MOE acting together should request the Ghana Regional Appropriate Technology Industrial Services (GRATIS), Accra Technical Training Centre (ATTC), Kumasi Technical Institute (KTI) and other technical institutions, the NBSSI and EMPRETEC, to mount an intensive training programmes in the requisite areas for these small scale entrepreneurs.

Capital

4.65 Lack of capital is a major constraint not only for small scale manufacturers of processing equipment but also for operators of root and tuber crops processing establishment. This is due, inter alia, to the high rates for capital, the negative perception of banks towards such enterprises due to their vulnerability and high mortality rates, inadequate loanable funds and poor repayment rate, weak credit system and the absence of specific institution(s) charged with small scale financing policy.
To solve this problem of capital, the Government of Ghana (GOG) should have a clearly-defined national policy on micro and small enterprises, establish specific financial institution charged with financing micro and small enterprises, and/or setting up a special credit scheme for micro and small enterprises.

Construction raw materials

4.66 The manufacturers of root and tuber processing machinery depend on scrap iron as raw material. The use of scrap does not provide the necessary material for food processing equipment where hygiene of the product is important and where contamination of the products needs to be avoided.

As a short-term measure the use of scrap may be satisfactory but not in the medium-term and long-term. Concerted efforts should therefore be made by MOTI and MOST to improve on the availability of construction raw materials especially iron and steel. For this, the Tema Steel Works needs to be upgraded and the proposed development of the Oppon Manso Iron and Steel Project should be undertaken.

Marketing

4.67 Although marketing has generally not been a major constraint since most of the manufacturers produce on order, there is the need to assist them with knowledge of marketing strategies and opportunities. The acquisition of this knowledge should form part of the curricula of their entrepreneurial training by NBSSI and EMPRETEC.

Suitability of Improved Cassava Varieties to Processing Methods

4.68 Three of the four varieties namely; TMS 30572, TMS 50395 and TMS 4(2)1425 have been released for their food values because of the following:

1. Yield (both wet and dry) of each of the above named clones is more than twice that of the local variety Ankra. It is therefore presupposed that their higher yield will result in higher returns for the farmers.

2. Although they have relatively higher HCN content than the local variety the levels appear to fall within safe limits in their food forms as the HCN contents are less than 10mg/100g.

3. All the three are at present tolerant to the common pests and diseases in the country.

4. The morphological characteristics of the three fit into the current farming systems of the country.

5. In addition to the above points, the clone TMS 50395 though not good for fufu or ampesi is good for gari, agbelima and kokonte. It has the highest yield and therefore is given the name Gblemo Duade (meaning in Ga grinding cassava). This variety is being recommended to be released for processing into gari, kokonte and agbelima.

6. Clone TMS 4(2)1425 has some unique morphological features. The roots are long and whitish in colour and the "Abasa fitaa" (meaning, white arms, in Akan language) has been given to it. This clone is recommended as all purpose cassava.

7. The clone TMS 30572 though not good for fufu and ampesi is good for gari, agbelima and kokonte. It has comparatively stable yield both on station and on farmers' fields throughout West Africa indicating higher adaptability to prevailing farming systems. For this quality the name "Afisiafi" (meansing in Ewe language, cassava with stable performance) has been given to it. It is recommended to be released for processing into gari, agbelima and kokonte.

8. Despite its favourable attributes which make it suitable for mechanical harvesting and fit into intercropping systems with various field crops the sub-committee could not recommend the clone TMS 91934 for release because of its high susceptibility to African Cassava Mosaic Virus Disease (ACMVD) and lowest yield among the four varieties. It should however be kept in the germplasm for expoitation of its good attributes by breeders.

9. The varieties could not be recommended for industrial uses because no data for that purpose were provided. It is hoped that future research would consider the relevant data including the content and nature of starch, fibre content and their suitability for animal feed.

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Annex 1

ROOT AND TUBER CROPS PROCESSING AT THE VILLAGE LEVEL IN GHANA

Q U E S T I O N N A I R E

1. GENERAL

1.1 Name of the processing unit/group/plant (underline whichever is relevant).....
.....

1.2 Address and location of the unit/group/plant (underline whichever is relevant).....
.....
.....

1.3 Name of district and region in which unit/group/plant is located (underline whichever is relevant)
.....
.....

1.4 Is unit/group/plant individually-owned (Yes/No)
family-owned.....group-owned (Yes/No)
.....institution-owned (Yes/No)
a non-governmental organization (NGO) sponsored project or funded (Yes/No).....
.....

1.5 If the unit/plant is individually-owned obtain the following particulars of the person:-

i. age: .....
ii. sex: .....
iii. marital status: .....
iv. educational status: .....
v. professional skills:.....

1.6 If the unit/plant is family-owned obtain the following particulars:-

i. name of the leader: .....
ii. number of men: .....
iii. number of women: .....

iv. number of children above 12 years old.....

v. number of children below 12 years old.....

vi. assignment of the leader .....

vii. assignment of the women.....
.....

viii. assignment of the men .....
.....

ix. assignment of the children above 12 year old
.....

x. assignment of the children below 12 years old
.....

1.7 If the unit/plant is group-owned obtain the following particulars:-

i. name of the leader of the group.....

ii. number of family subgroups.....

iii. average number of persons in each subgroup.....

iv. number of men and their assignments in each subgroup.....

v. number of women and their assignments in each subgroup.....
.....

vi. number of children above 12 years and their assignments in each subgroup.....
.....

vii. number of children below 12 years and their assignments in each subgroup.....
.....

1.8 If the unit/group is institution-owned obtain the following particulars:-

i. name of the institution.....

ii. name of the manager .....

iii. age .....

iv. sex.....

v. educational status.....

vi. professional status.....

vii. numbers of management personnel.....

viii. number of machine operators.....

ix. number of supervisory personnel.....

x. number of unskilled labour.....

1.9 If the unit/plant is a non-governmental (NGO) funded project, name of the (NGO).....

.....

1.10 If unit/plant is a NGO funded project name other places village(s) district(s) and region(s) where the NGO has similar projects.....

.....

.....

1.11 Name(s) of the beneficiaries (groups or institutions or organizations of the NGO funded projects.....

.....

1.12 Name of the management of such NGO funded projects...

.....

.....

2. RAW MATERIALS

2.1 Do you grow your own raw materials (cassava, yam, cocoyam, sweet potato, frafra potato) for processing?

.....

.....

Yes/No.

2.2(a) If no in 2.1 where then are the sources of your raw materials supply?.....

.....

2.2(b) What varieties of raw materials (cassava, yam, etc) do you get from the various sources? Name them

.....

.....

2.2(c) What characteristics (time to mature, starch content, colour) do these raw materials have?.....

.....

.....

2.3 If you grow your own raw materials (cassava, yams, cocoyam, sweet potato, frafra potato) what are the names of the varieties you grow and why do you grow these rather than others?

.....

.....

.....

.....

2.4 What peculiar characteristics do the varieties you grow have which are different from the others you do not grow?.....

.....

.....

2.5(a) Do you think the age and variety of the raw materials (cassava, yams, cocoyam, sweet potato, frafra potato) affect the quality of the processed products (gari agbelima, starch tapioca etc).

.....

.....

.....

2.5(b) What effects do you normally notice? Please complete table below.

RAW MATERIAL	VARIETY	AGE	EFFECTS

2.6(a) If the raw materials (cassava, yams etc) are from your own farms how far are there farms from the processing site?.....

.....

.....

2.6(b) If the raw materials are from co-operative farms, how far are they from the processing site?

.....

.....

2.6(c) If the raw materials are from individual farms how far are they from the processing site?

.....

.....

2.6(d) If the raw materials are from villages how far away are these villages from the processing site?

.....

.....

2.7 How are the raw materials brought to the processing site?

by means a tractor .....

by means of a truck .....

by means of a donkey cart.....

by means of headloads .....

others specify .....

2.8(a) Give approximate periods of the year when the raw materials are most abundant for processing (dates)

.....

.....

2.8(b) What are the peak and lean seasons for raw materials in your area or village? Please complete the table below.

VILLAGE	RAW MATERIAL	PEAK SEASON	LEAN SEASON	REMARKS

2.9 What are the costs of the raw materials when in peak season and when in lean season?

RAW MATERIAL	COST/KG		COST PER BAG OF KG	
	Peak Season	lean Season	peak Season	lean Season

2.10 Do you store your raw materials when you purchase or harvest them?..... Yes/No.

2.11(a) If yes in 2.10, how do you store them? Describe the storage method for each type of raw material you process (add more sheets if necessary)

.....
.....
.....
.....
.....
.....

2.11(b) Do you treat the raw material in some way before storing?.....Yes/No.

2.11(c) If yes in 2.11(b), then describe the treatment given?.....
.....
.....
.....

2.12 For how long do you store the raw materials before processing?.....
.....

2.13 What is the maximum and minimum quantities of raw material needed for processing in

i. a day .....
ii. a week .....
iii. a month .....
iv. others specify .....

2.14 What problems do you generally face with raw materials supply?

.....
.....
.....
.....

3. WATER REQUIREMENTS

3.1 From where is water obtained for processing?

i. a well .....
ii. a river (name) .....
iii. a spring (name) .....
iv. a lake (name) .....
v. storage tank (capacity).....
vi. borehole .....
vii. others specify .....

3.2(a) Have these different types of water sources been tested as to their suitability for drinking (Yes/No)

3.2(b) If yes in 3.2(a) by whom and when

.....
.....
.....

3.2(c) If no in 3.2(a), then is the water being used in the locality for drinking purposes.....(Yes/No)

3.3 How is the water brought to the processing unit?

i. by means of pipe lines.....
ii. in containers.....
iii. in trucks/tractors .....
iv. by means of headloads .....
v. Others specify .....

4. ENERGY REQUIREMENT

4.1 What is your main source of power for operating the machines.

i. from a generating plant (Yes/No) what is its capacity .....(KVA).....

ii. from electricity corporation of Ghana (ECG) substation (Yes/No). Where and how far is the substation located.....

iii. from a diesel engine (Yes/No). Obtain particulars of the diesel engine.

4.2 What is your energy sources for roasting.

i. electricity.....(Yes/No)

ii. gas .....(Yes/No)

iii. fuelwood .....(Yes/No)

iv. Others specify .....

5. MANPOWER

5.1 What is your total labour force in respect of

i. management.....

ii. technical supervision .....

iii. line/machine operators.....

iv. casual labour in peak season.....

v. casual labour in lean season .....

5.2 What are your labour requirements (person-hour, person-day) in respect of the following according to the table below.

OPERATION	PEAK SEASON	LEAN SEASON
Peeling Washing Grating Pressing Sieving Roasting Bagging		

5.3 What are your total labour requirements (person-hour, person-day) for making

i. gari .....
ii. agbelima.....
iii. starch.....
iv. tapioca.....
v. kokonte.....
vi. others specify.....

6 PROCESSING TECHNOLOGY

6.1 What are the objectives of the processing or the processing technology? Are they meant to

i. transform a highly perishable crop into a product of longer storage life (Yes/No)
ii. detoxify and transform a highly perishable crop into a product of longer storage life (Yes/No)
iii. meet the consumer demand for a staple food (Yes/No)
iv. meet market demand (Yes/No)
v. transform highly perishable crop into a more convenient and easily marketable form (Yes/No)
vi. satisfy the eating habit of a section of population (Yes/No)
vii. meet export demand (Yes/No)
viii. Others specify .....

6.2(a) In your opinion do you think the technology you are using is indigenous or imported?

.....
.....

6.2(b) If indigenous, from which are (village, district, region) did it originate?

.....
.....

6.2(c) If imported from which country?.....
.....

6.3 What are the processing methods you use in the production of items you produce? Describe the unit operations of processes involved according to the table below (attach more sheets if necessary.

PRODUCT	PROCESSING METHOD

6.4 Indicate the amount of processed product obtained from a specific quantity of raw material (recovery rate) in the table below.

PRODUCT	RAW MATERIAL(KG)	PROCESSED PRODUCT(KG)	RECOVERY RATE(%) PROCESSED PROD.X100 / RAW MATERIAL

6.5 Indicate in the table below the manner of utilization and the percentage used of the processed product.

PROCESSED PRODUCT	UTILIZATION						
	As Food	% Used	As Feed	% Used	Industrial Material	% Used	Others (specify)

7 MACHINERY

What types of machines do you have for processing the raw materials? Could you give the approximate number of units, capacity, year of make, year of installation and materials of construction etc. of these machines as per the table below.

Type of Machine	No of Units	Capacity	Power Rating	Year of Purchase and Install.	Component Construction Materials
Washer					
Peeler					
Grater					
Presser					
Heat Sealer					
Dryer					
Sieve					
Roaster					
Grinder					
Fermenting equipment					
Others (specify)					

71. List other methods by which the above machines are operated (eg. fuel wood, diesel, biogas, solar etc.)

.....

.....

.....

.....

7.2 What is the cost of each of the machines listed in question 7.1?

a. ..... b. ..... c. .....

d. ..... e. ..... f. .....

g. ..... h. ..... i. .....

7.3 If constructed by you, what are their costs.

.....

.....

.....

7.4 If not manufactured by you, by whom were they manufactured? (Address)

.....

.....

.....

Where does the manufactures have his factory?

.....

.....

.....

7.5 What do you think the total cost of all the machines you use is?

.....

.....

7.6 How many hours are each of the machines operated in a day.

.....

How many days in a week.....

How many weeks or days in a month.....

How many months, weeks or days in a year.....

7.7 How often does each machine break down, in-

a. a day .....

b. a week .....

c. a month .....

d. a year .....

7.8 Give the average number of days each machine may be idle due to

a. lack of spare parts .....

b. due to lack of raw materials.....

.....

c. due to lack of customers .....

.....

7.9 Are spare parts for the parts of each machine readily available.....

.....

.....

Can they be purchased in the shops.....

Can they be obtained from the manufacturers .....

.....

8. END-PRODUCTS

8.1 What products do you produce from the raw materials (List)..... .....

....

8.2 Give the quantities produced in a day, in a week, in a month, in a year according to the table below (kg).

In a day	In a week	In a month	In a year

9. BY-PRODUCTS

9.1 What are the by-products of your processing activities (List them).....

.....

.....

9.2 How do you use the by-products.

By-Product	Use

10 WASTE DISPOSAL

10.1 How do you dispose of wastes?

Waste	Method of Disposal

11. DISTRIBUTION AND MARKETING

11.1 How are the end products distributed and marketed? (Give name and/or address, if possible)

Gari

a. through agents.....

d. direct to consumers .....

c. sale to agencies/institutions.....

.....

d. at the market .....

Agbelima

a. through agents.....
d. direct to consumers .....
c. sale to agencies/institutions.....
.....
d. at the market .....

Kokonte

a. through agents.....
d. direct to consumers .....
c. sale to agencies/institutions.....
.....
d. at the market .....

Starch

a. through agents.....
d. direct to consumers .....
c. sale to agencies/institutions.....
.....
d. at the market .....
Others (Specify).....

11.2 Who are your biggest customers? Give name and/or address.

a. The agents.....
b. The consumers.....
c. The agencies.....
d. Organisations/Institutions.....
e. Others (specify).....

11.3 Are there any guaranteed prices for each of these commodities?
What are the prices paid per unit quantity when raw material is in season and when cassava is out of season?

In season (¢)	Lean season (¢)
Starch Gari Kokonte Tapioca Others (specify)	

11.4 By what means of transport do you frequently market your products (Tick whichever is relevant)

i. by land (lorry) ii. by rail

iii. by air iv. by sea

11.5 Where do you market your products (Tick whichever is relevant and name them.

i. In your area of production .....

ii. Outside your area.....

iii. Outside Ghana.....(Name the countries)

11.6 How are your products packaged for distribution and marketing (Tick one which are relevant)

i. in jute sacks ii. in polypropylene sacks

iii. in plain polythene ponches iv. in printed and decorated polythene ponches v. in metal containers

vi. in glass containers

11.7 How were your markets determined?

.....

.....

.....

.....

11.8 When are your peak marketing (i) day(s) of the week (ii) week(s) of the month..... month(s) of the year.

11.9 What other information do you have on your marketing strategy.

.....

.....

.....

.....

12. ASSESSMENT OF PROCESSING UNIT

12.1 Machines

i. External appearance .....

ii. Efficiency (give percentage).....

iii. Output or capacity.....

iv. Frequency of use.....

v. Hygienic and sample condition.....

12.2 Processing

Sanitary and hygienic condition of area.....

.....

.....

12.3 Water used

From visual examination assess the quality of water used for washing and processing of raw materials.

.....

.....

.....

12.4 Technical assistance

What type of technical assistance do you as surveyor, think the unit needs.

.....

.....

.....

.....

12.5 Technical assistance needs

(This has to be obtained from the people)

What type of technical assistance do you need to improve processing of root and tuber crops in your unit?.....

.....

.....

.....

.....

.....

.....

12.6 Would you like to join with other units to work on co-operative basis?

.....

.....

.....

13. ANY OTHER INFORMATION RELEVANT TO THE SURVEY

.....

.....

.....

.....

.....

.....

.....

.....

ROOT AND TUBER CROPS PRESERVATION AT THE VILLAGE LEVEL IN GHANA

Q_U_E_S_T_I_O_N_N_A_I_R_E

1. GENERAL

1.1 Name(s) and Address(es) of the owner of the unit....
.....
.....
.....
.....

1.2 Location of the unit .....
.....
.....

1.3 Name of district and region in which unit is located
.....
.....

1.4 Is unit individually - owned (Yes/No). Family - owned (Yes/No). Group - owned (Yes/No). A non-governmental organization (NGO) sponsored project or funded (Yes/No).

1.5 If the unit is individually-owned obtained the following particulars of the person:

i. age .....
ii. sex.....
iii. marital status .....
iv. educational status .....
v. professional skill .....

1.6 If the unit is family-owned obtain the following particulars:

i. name of the leader .....
ii. number of men .....
iii. number of women .....
iv. number of children below 12 years old .....
v. number of children above 12 years old .....
vi. assignment of the leader .....
vii. assignment of men .....
viii.assignment of women.....

xi. assignment of children below 12 years old.....
.....

x. assignment of children above 12 years old.....
.....

1.7 If the unit is group-owned obtain the following particulars:

i. name of the leader of the group.....
.....

ii. number of family sub groups.....

iii. average number of person in each sub group
.....

iv. number of women and their assignments in each sub group.....

iv. number of children below 12 years and their assignments in each sub group.....

iv. number of children above 12 years and their assignments in each sub group.....

1.8 If the unit is institution-owned obtain the following particulars:

i. name of the institution .....
.....

ii. name of the manage .....

iii. age .....

iv. sex. .....

v. educational status .....
.....

vi. professional stuatus .....
.....

vii numbers of management personnel.....

viii.number of unskilled labour .....

1.9 If the unit is a non-governmental (NGO) funded project, name of the (NGO).....

1.10 If the unit is a NGO funded project name other places (villages) district(s) and regions where the NGO has similar projects.....
.....

1.11 Name(s) of the beneficiaries (groups or institution or organizations) of the NGO funded projects .....
.....
.....

1.12 Name of the management of such NGO funded projects
.....
.....
.....

2 CROPS GROWTH

2.1(a)What types of root and tuber crops do you grow?
Name them.....
.....
.....

2.1(b)Do you sell all what you grow. (Yes/No)

2.1(c)If no in 21b, then how much of what you grow do you preserve/store?

i. 1/4 ..... Yes/No
ii. 1/3 ..... Yes/No
iii. 1/2 ..... Yes/No
iv. 2/3 ..... Yes/No
v. 3/4 ..... Yes/No
vi. Others (specify)

2.2 If you do not grow your own root and tuber crops, then which types do you purchase or obtain to sell or to preserve/store? Name them .....
.....
.....
.....

2.3 What quantities of crops name in 2.2 do you purchase or obtain and how much of them do you preserve/store? Indicate the information in the table below:

CROP	QUANTITY PURCHASED	QUANTITY STORED	PERCENTAGE (%) STORED

3. STORAGE METHODS AND STRUCTURES

3.1 If you preserve/store part of your root and tuber crops, describe in the table below the methods and structures you use for each crop and the storage period.

CROP	STORAGE METHODS & STURCTURES	STORAGE PERIOD

3.2 What materials do you use for the construction of the storage structures and where are they obtained?

i. sticks (sizes) .....

ii. dry sorghum stalks .....

iii. tie-vine .....

iv. twigs (thorned) .....

v. poles .....

vi. others (specify).....

3.3 How many days does it take to construct a storage structure (days)?

i. by one person .....

ii. by two persons .....

iii. by three persons .....

iv. others (specify) .....

3.4 Who are involved in the construction of the structures?

i. men only (Yes/No)

ii. men and women (Yes/No)

iii. men and children (Yes/No)

iv. men, women and children (Yes/No)

v. family members only (Yes/No)

vi. family members and neighbours (Yes/No)

vii. family members and hired labour (Yes/No)

viii. others (specify) .....

3.5 What is the life span of storage and dry structures?

i. storage barn.....

ii. storage room (mud) .....

iii. elevated drying platform .....

iv. others (specify) .....

3.6 When are the crops stored?

i. soon after harvest (Yes/No)

ii. a few days after harvest (Yes/No)

iii. a week after harvest (Yes/No)

iv. soon after purchase (Yes/No)

v. a week after purchase (Yes/No)

3.7 Does the delay in storing the the crop soon after harvest affect the crop? (Yes/No). If yes, in what way(s) describe .....
.....
.....
.....

4. SPOILAGE

4.1 If even when the crops are stored soon after harvest some of them get spoiled, could you give some details as to the quantities spoiled and how long it takes to get spoiled. Please complete the table below:

CROP	STORAGE METHOD	QUANTITY STORED	QUANTITY SPOILED	PERIOD TO SPOILAGE (MONTHS)	PERCENTAGE SPOILAGE(%)

4.2 What are the causes and nature of spoilage for each of the crops when in storage? Please complete the table below:

CROP	CAUSE OF SPOILAGE	NATURE OF SPOILAGE

4.3 Do you process some of your harvested process before storage. (Yes/No)

4.4 If yest in 4.3 then describe the processing method, months of the year when the processing is done, how long it stores before you notice spoilage, and the cause of spoilage according to the table below. (add more sheets if necessary):

CROP	PROCESSING METHOD	TIME PROCESSED (CALENDAR MONTHS)	STORAGE PERIOD	CAUSE OF SPOILAGE

5. DISTRIBUTION AND MARKETING

5.1 Where do you market your products (name them)

.....

.....

.....

5.2 How do you market your products?

i. in baskets (Yes/No)

ii. in jute sacks (Yes/No)

iii. in basin (metal) (Yes/No)

iv. others (specify) .....

5.3 How do you convey them to the markets?

i. by means of trucks(lorries) Yes/No)

ii. by means of tractors (Yes/No)

iii. on bicycles (Yes/No)

iv. on horseback (Yes/No)

v. by means of river boat or canoe (Yes/No)

vi. by headload

vii. others (specify)

5.4 Where do you store them in the market (name them)

.....

.....

.....

5.5 How much do you sell your produce during the peak and lean seasons? Please complete the table below:

PRODUCT/PRODUCE	PRICE	
	PEAK SEASON	LEAN SEASON

6. TECHNICAL ASSISTANCE NEEDS

6.1 What assistance do you need to help you store and preserve your root and crops to prevent losses?

.....

.....

.....

.....

.....

.....

.....

SMALL SCALE ROOT AND TUBER CROPS PROCESSING
AND PRESERVATION EQUIPMENT PRODUCED IN GHANA

Q_U_E_S_T_I_O_N_N_A_I_R_E

1. Name and address of organization.....
.....
.....
.....

2. Location of the factory (House/Street No.) .....
.....
.....

3. Name of owner or proprietor .....
.....

4. Year of establishment .....

5. Range of equipment produced and their costs. Please complete the table below:

EQUIPMENT		COST (¢)
PROCESSING	PRESERVATION	

6. Which persons and/or organizations are the main buyers of your equipment?

   i. persons (name them)
   .....
   .....
   .....
   .....

   ii. organizations (name them)
   .....
   .....
   .....

7. Please complete the table below on the various types of equipment produced for processing and preserving root and tuber crops:

DATA ON EQUIPMENT P ODUCED

NAME OF EQUIPMENT	NAME OF MANUFAC TURER	COST OF EQUIPMENT & POWER UNIT	USES	CAPACITY (KG/HR)

POWER CONSUMPTION (KW)		LABOUR REQUIREMENT	MAIN COMPONENT PARTS CONSTRUCTION MATERIALS
DIESEL	ELECTRIC		

FLOOR SPACE REQUIRE MENT	LIFE SPAN (YEARS)	FREQUENCY OF PART REPLACE MENT	MAINTENANCE REQUIREMENT	SERVICING REQUIREMENT

8. PRODUCTION CONTROL

8.1 Do you carry out production control of the equipment you produce? (Yes/No)

8.2 If yes in 8.1, describe how this is done .....
.....
.....
.....
.....

9. HARDWARE

9.1 Where do you obtain some of the materials for your production work?

i. sheet metal.....

ii. angle iron .....

iii. shaft .....

9.2 Are some of the materials scrap. (Yes/No)

9.3 If yes in 9.2 where do you obtain the scrap materials
.....
.....
.....
.....

10 WORKSHOP MACHINERY

10.1 What types of machinery do you have in your workshop for producing the various equipment (Name them)

.....

.....

.....

.....

11 LABOUR

11.1 What is your labour strength?

i. management .....

ii. engineers .....

iii. technicians .....

iv. semi-skilled .....

v. unskilled .....

12. ASSISTANCE NEEDS

12.1 What technical assistance would you need to improve upon your production technique?

.....

.....

.....

.....

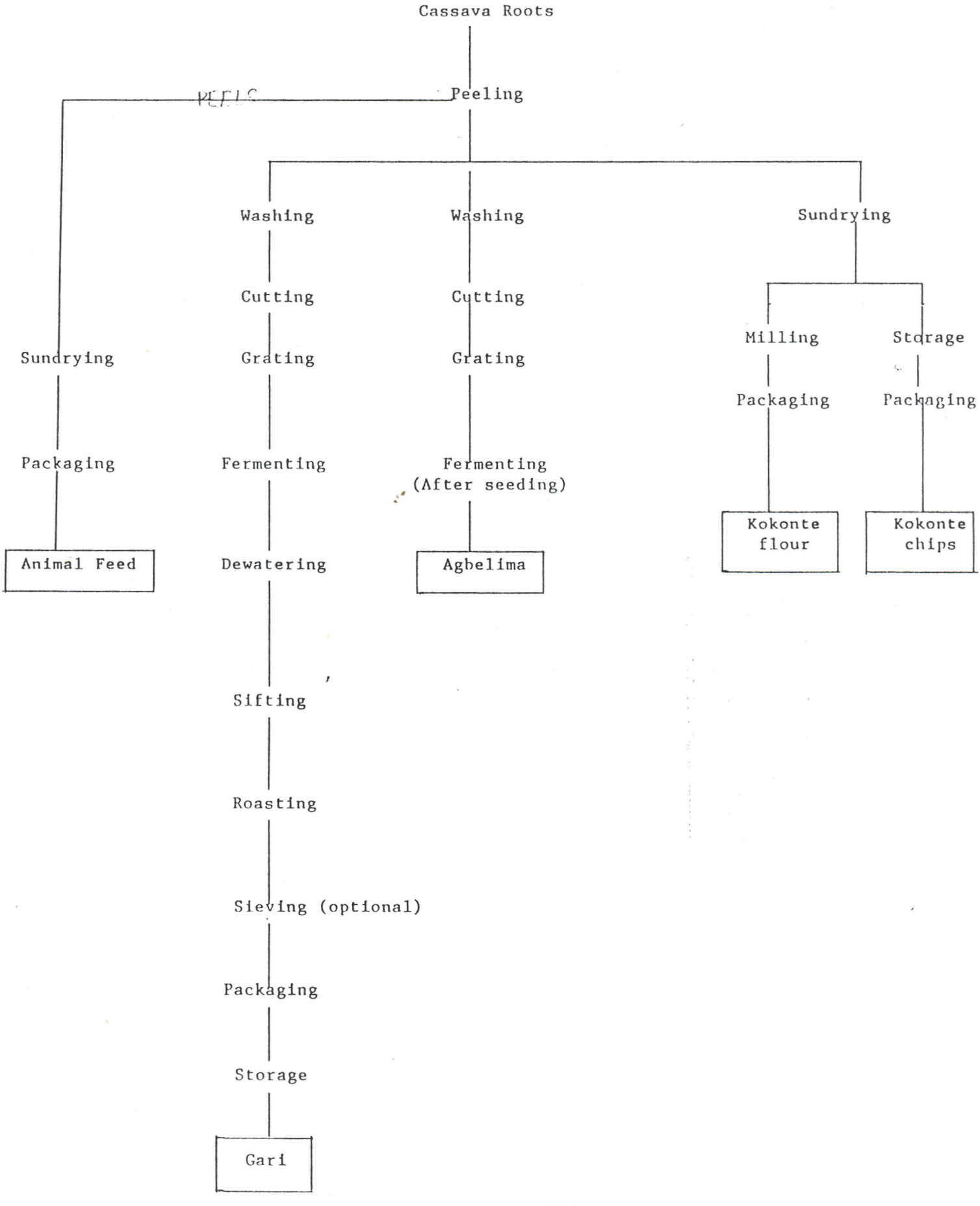
.....

.....

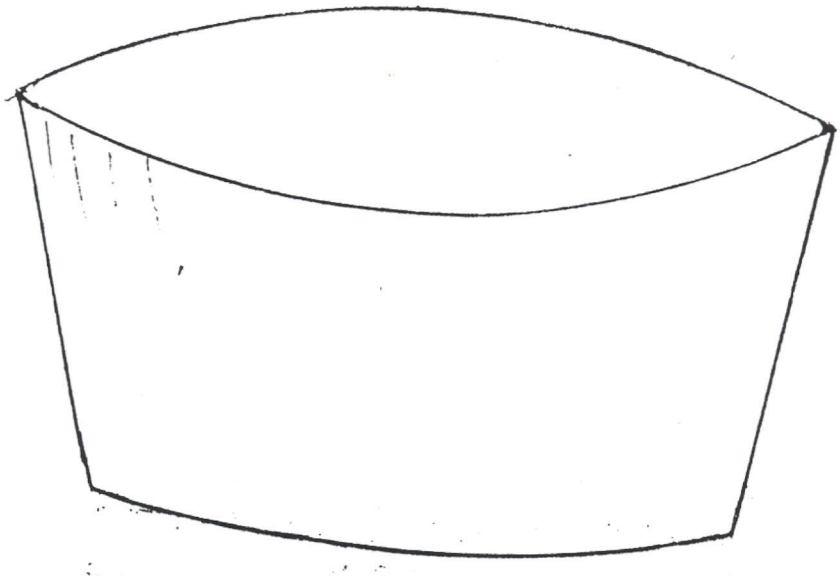
.....

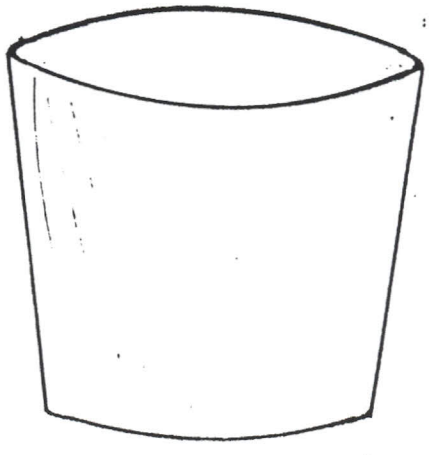
Annex 2

FLOW DIAGRAM OF VILLAGE LEVEL PROCESSES OF CASSAVA



Annex 3





Annex 4

CASSAVA PROCESSING UNITS AND THEIR LOCATIONS

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Ashanti	Ejisu-Juaben	[1]Kwamo	Gari Making
	"	Achinakrom Women group	"
	Atwima	[1]Nkroma	"
	Sekyere West	[1]Brofoyedu	"
	Ahafo-Ano North	[1]Tepa	"
	Asanti Akim South	[1]Juaso	"
	"	[1]Odubi	"
	" North	[1]Nyirumpense	"
	Ejura Sekyedumasi	[1]Sekyedumasi	"
	Agona	[1]Agona	"
	Adansi West	[1]Adomanu	"
	Kwabre	[1]Antoa	"

[1]31st D.W.M. - 31st December Womens' Movement Unit

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Brong-	Sunyani	[1]Faakro	Gari Making
Ahafo	"	[1]Wawasua	"
	Dormaa	[1]Duasidan	"
	"	[1]Kwame Ningo	"
	Asutifi-Kenyasi	[1]Dadee Soaba	"
	Kintampo	[1]Ntanleoro	"
	"	[1]Apesika	"
	Sene-Kwame Danso	[1]Jemu	"
	"	[1]Drobe	"
	Nkoranza	[1]Asekye/Krukese	"
	"	[1]Asunkwa	"
	Techiman	[1]Buoyum	"

[1]31st D.W.M. - 31st December Womens' Movement Unit

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Ashanti	Ejisu-Juaben	[1]Kwamo	Gari Making
	"	Achinakrom Women group	"
	Atwima	[1]Nkroma	"
	Sekyere West	[1]Brofoyedu	"
	Ahafo-Ano North	[1]Tepa	"
	Asanti Akim South	[1]Juaso	"
	"	[1]Odubi	"
	" North	[1]Nyirumpense	"
	Ejura Sekyedumasi	[1]Sekyedumasi	"
	Agona	[1]Agona	"
	Adansi West	[1]Adomanu	"
	Kwabre	[1]Antoa	"

[1]31st D.W.M. - 31st December Womens' Movement Unit

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Brong-Ahafo	Sunyani	[1]Faakro	Gari Making
	"	[1]Wawasua	"
	Dormaa	[1]Duasidan	"
	"	[1]Kwame Ningo	"
	Asutifi-Kenyasi	[1]Dadee Soaba	"
	Kintampo	[1]Ntanleoro	"
	"	[1]Apesika	"
	Sene-Kwame Danso	[1]Lemu	"
	"	[1]Drobe	"
	Nkoranza	[1]Asekye/Krukese	"
	"	[1]Asunkwa	"
	Techiman	[1]Buoyam	"

[1]31st D.W.M. - 31st December Womens' Movement Unit

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Central	Komenda-Edina -Equafo	[1]Komenda	Gari Making
	"	[1]Nyiaye	"
	"	[1]Anweem	"
	"	[1]Kwame Ta	"
	Abura Asebu- Kwamnakese	New Abu	"
	"	Old Abu Aboanu	"
	"	Asuansi	"
	"	Abaasi	"
	"	Abakrampa Sorodofo	"
	"	Asomdwee	"
	"	Nyame dom	"
	"	Paboako Kwamang	"
	"	Anweemu	"
	Awutu-Efutu -Senya	Obrakyere	"
	"	Bawjiase	"
	Cape Coast	Pedu	"
	"	Abura	"
	"	Kawanopado	"
	"	Dehia	"
	Asikuma-Odoben -Brakwa	Ahwiam	
	"	Essuman Gyira	"
	Twifo Heman- Lower-Denkyira	Jukwa	"
	"	Achiase	"
	"	Atobiase	"
	Upper Denkyira	Akropong	"
	Assin	Achiase	"
	Gomoa		

[1]31st D.W.H. - 31st December Womens Movement Unit

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Central	Komenda-Edina -Equafo	[1]Komenda	Gari Making
	"	[1]Nyiaye	"
	"	[1]Anweem	"
	"	[1]Kwame Ta	"
	Abura Asebu- Kwamnakese	New Abu	"
	"	Old Abu Aboanu	"
	"	Asuansi	"
	"	Abaasi	"
	"	Abakrampa Sorodofo	"
	"	Asomdwee	"
	"	Nyame dom	"
	"	Patoako Kwamang	"
	"	Anweem	"
	Awutu-Efutu -Senya	Obrakyere	"
	"	Bawjiase	"
	Cape Coast	Pedu	"
	"	Abura	"
	"	Kawanopado	"
	"	Dehia	"
	Asikuma-Odoben -Brakwa	Ahwiam	
	"	Essuman Gyira	"
	Twifo Heman- Lower-Denkyira	Jukwa	"
	"	Achiase	"
	"	Atobiase	"
	Upper Denkyira	Akropong	"
	Assin	Achiase	"
	Gomoa		

[1]31st D.W.M. - 31st December Womens' Movement Unit

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Eastern	Akuapem-North	[2]Kwamoso	Gari Making
		Yensiso	"
		[3]Mampong Nkwanta	"
		Nkwanta	"
		"	"
		Adawso/Apasare	"
		Korkormy	"
		"	"
		"	"
		Atobiase	"
		Akropong	"
		Achiase	"
		Korkormu	Gari/Agbelima
	Akuapem South	[4]Oblegimah	"

2 - There are nine (9) processing units in Kwamoso
3 - There are three (3) processing units in Mampong-Nkwanta
4 - There are five (5) processing units in Oblegimah

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Eastern	Akuapem-North	[2]Kwamoso	Gari Making
		Yensiso	"
		[3]Mampong Nkwanta	"
		Nkwanta	"
		"	"
		Adawso/Apasare	"
		Korkormy	"
		"	"
		"	"
		Atobiase	"
		Akropong	"
		Achiase	"
		Korkormu	Gari/Agbelima
	Akuapem South	[4]Oblegimah	"

[2] - There are nine (9) processing units in Kwamoso
[3] - There are three (3) processing units in Mampong-Nkwanta
[4] - There are five (5) processing units in Oblegimah

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
		[5]Amanse	Gari/Agbelima
		[6]Mamkrong	"
	Suhum/Kraboa		
	"	[7]Kae-Owuo-Nkwanta	"
		[8]Wanbenya	"
		Nyakmah	Gari Making
		Adaham	"
		Kentenkron	"
		Kwakyia	"
		Ntronang	"
		Korle Nkwanta	"
		Nyered	"
		Densuagya	"

[5] - There are seven (7) processing units in Amanse

[6] - There are nine (9) processing units in Mamkrong

[7] - There are four (4) processing units in Kae-Owuo-Nkwanta

[8] - There are four (4) processing units in Wanbenya

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
		[5]Amanse	Gari/Agbelima
		[6]Mamkrong	"
	Suhum/Kraboa		
		[7]Kae-Owuo-Nkwanta	"
		[8]Wanbenya	"
		Nyakmah	Gari Making
		Adaham	"
		Kentenkron	"
		Kwakyia	"
		Ntronang	"
		Korle Nkwanta	"
		Nyered	"
		Densuagya	"

[5] - There are seven (7) processing units in Amanse

[6] - There are nine (9) processing units in Mamkrong

[7] - There are four (4) processing units in Kae-Owuo-Nkwanta

[8] - There are four (4) processing units in Wanbenya

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Greater Accra	Dangme West	Agomeda Gari Unit	Agbelima Making
		Dodowa Home Unit	Gari Making
		Sota Farms	"
		Dawa Unit	"
		Dodowa Town	Agbelima Making
		Dodowa Odumasi	Yakayeke
		Ablekuma	Agbelima Making
		Aperkon	Agbelima/Gari Making
	Dangme Wast	Adokope Unit	"
		Koluedo Group	"
		Mantse Kope	"
		Kasseih	Agbelima Making
		Ada Foah	Gari Making
		Ocanse Kobe	Agbelima/Gari Making
		Adortorkope	"
		Makartekope	Agbelima Making
		Anyakpor	Agbelima/Gari Making
		Pokuase Unit	"
		Amasaman	"
		Pobiman	"
		Kutunse	"
		Mayera	"
		Oyansanaa	Agbelima Making
		Kokrobite	"

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Greater Accra	Dangme West	Agomeda Gari Unit	Agbelima Making
		Dodowa Home Unit	Gari Making
		Sota Farms	"
		Dawa Unit	"
		Dodowa Town	Agbelima Making
		Dodowa Odumasi	Yakayeke
		Ablekuma	Agbelima Making
		Aperkon	Agbelima/Gari Making
	Dangme Wast	Adokope Unit	"
		Koluedo Group	"
		Mantse Kope	"
		Kasseih	Agbelima Making
		Ada Foah	Gari Making
		Ocanse Kobe	Agbelima/Gari Making
		Adortorkope	"
		Makartekope	Agbelima Making
		Anyakpor	Agbelima/Gari Making
		Pokuase Unit	"
		Amasaman	"
		Pobiman	"
		Kutunse	"
		Mayera	"
		Oyansanaa	Agbelima Making
		Kokrobite	"

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Western	Shama Ahanta East	Asemasa/Shame Junc.	Gari Making
		Kwasimintim	"
		Beposo	"
		Nkrofulit	"
		Diabenekrom	"
		Kansaworodu Awotsoe Nkwanta	"
		Apimenyim	"
		[1]Atanta(Beposo)	"
		[1]Asamansudo	Gari, Tapoca &starchmaking
		[1]Essipong	Gari making
		Agona Nkwanta	"
		Abura	"
		[1]Cape Three Points	"
		Nsuem	"
		Asuoja	"
		Wassa-Nkram	"
		Peasa	"
		Daboasi	"
		Mpeasem	"
		[1]Bibiani	"
		Anyinasi	"
		[1]Nkroful	"
	Sefwi Wiawso	Wiawso	"
		[1]Tikobo	Agbelima Making
		[1]Nyame Adiso	"
	Wassa Amenfi	Asankragwa	

[1] - 31st December Womens' Movement Unit

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Western	Shama Ahanta East	Asemasa/Shame Junc.	Gari Making
		Kwasimintim	"
		Beposo	"
		Nkrofulit	"
		Diabenekrom	"
		Kansaworodu Awotsoe Nkwanta	"
		Apimenyim	"
		[1]Atanta(Beposo)	"
		[1]Asamansudo	Gari, Tapoca &starchmaking
		[1]Essipong	Gari making
		Agona Nkwanta	"
		Abura	"
		[1]Cape Three Points	"
		Nsuem	"
		Asuoja	"
		Wassa-Nkram	"
		Peasa	"
		Daboasi	"
		Mpeasem	"
		[1]Bibiani	"
		Anyinasi	"
		[1]Nkroful	"
	Sefwi Wiawso	Wiawso	"
		[1]Tikobo	Agbelima Making
		[1]Nyame Adiso	"
	Wassa Amenfi	Asankragwa	

[1] - 31st December Womens' Movement Unit

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Volta	Ho	Kpenoe	Gari/Agbelima Making
		Takla Gbogame	"
		[1]Takla Tokor	"
		Hodzo - Ga	"
		[1]Hodzo Aviepe	"
		Hodzo Achanse	"
		Hodzo Kope	"
		Abutia Teti	"
		Adaklu Sofa	"
		Akrofu Xeviewefe	"
		Adaklu Ahunda	"
		Boso/Kpodzi	"
		Adaklu Ablornu	"
		Saviefe	"
		Adaklu Safe	"
		Hodzoga	"
		Dodome	"
	Hohoe	Gari Kope	
		Fodome	"
		Gbi Wogbe	"
		Have Ando	"
		Ve - Koloenu	"
		Alavanyo - Kpeme	"
		Agate	"
		Ve - Golokwati	"
		Ve - Dome	"

1 - 31st December Womens' Movement Unit

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Volta	Ho	Kpenoe	Gari/Agbelima Making
		Takla Gbogame	"
		[1]Takla Tokor	"
		Hodzo - Ga	"
		[1]Hodzo Aviepe	"
		Hodzo Achanse	"
		Hodzo Kope	"
		Abutia Teti	"
		Adaklu Sofa	"
		Akrofu Xeviewefe	"
		Adaklu Ahunda	"
		Boso/Kpodzi	"
		Adaklu Ablornu	"
		Saviefe	"
		Adaklu Safe	"
		Hodzoga	"
		Dodome	"
	Hohoe	Gari Kope	
		Fodome	"
		Gbi Wegbe	"
		Have Ando	"
		Ve - Koloenu	"
		Alavanyo - Kpeme	"
		Agate	"
		Ve - Golokwati	"
		Ve - Dome	"

[1] - 31st December Womens' Movement Unit

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
	Kpando	Sevie	Agbelima/Gari Making
		Tsrukpe Tota	"
		Anfoe	"
		Botoku	"
		Botoku Tove	"
		Kubdzra	"
		Tsrukpe	"
		Dunyo Village	"
	Akatsi	Gbefi	"
		Dagbamatey	"
		Torve	"
		Abor	"
		Glikpome	"
		Kpoxe	"
		Akwave	"
		Avenofedo	Tapioca
	Ketu	Dzodze	Gari Making
		Penyi	Agbelima/Gari Making
		Klikor	"
		Sasiemie	"
		Dodo Pepesu	"
	Kadjebi	Dodo Amanfrom	"
		Asatu	"
		Dapaa	"
		Dodo Dompa	"
	Nkwanta	Korantang	"
		Pusurupu	"
		Kachiebi	"
		Dadevise	"
		Kevi	"
		Brewaniase	"
		Tinggase	"
		Mango Akura	"
		Dadiease	"
		Jumbo	"

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
	Kpando	Sevie	Agbelima/Gari Making
		Tsrukpe Tota	"
		Anfoe	"
		Botoku	"
		Botoku Tove	"
		Kubdzra	"
		Tsrukpe	"
		Dunyo Village	"
	Akatsi	Gbefi	"
		Dagbamatey	"
		Torve	"
		Abor	"
		Glikpome	"
		Kpoxe	"
		Akwave	"
		Avenofedo	Tapioca
	Ketu	Dzodze	Gari Making
		Penyi	Agbelima/Gari Making
		Klikor	"
		Sasiemie	"
		Dodo Pepesu	"
	Kadjebi	Dodo Amanfrom	"
		Asatu	"
		Dapaa	"
		Dodo Pompa	"
	Nkwanta	Korantang	"
		Pusurupu	"
		Kachiebi	"
		Dadevice	"
		Kevi	"
		Brewaniase	"
		Tingease	"
		Mango Akura	"
		Dadiease	"
		Jumbo	"

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
	Kete-Krachi	Borae No.2	"
	South Tougu	Agave Afedome	"
		Larve	"
		Fieve	"
		Sogakope	"
	North Tougu	Avetsi	"
		Mafi-Kumase	Agbelima/Kokonte/ Gari making
	Anlo	Mafi-Deveme	Tapioca/Agbelima Starch Biscuits making

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Northern	Damongo	Achubunyo	Gari Making
		Kanato	Kokonte/ Gari Making
		Laribanga	"
		Soalepe	"
		Damongo Town	"
		Kpandai Women Gp.	Gari Making
		Mankango	Kokonte/ Gari making
		Katejeli	"
		Kubaimata	"
		Kubiamata	"
		Kanbonwule	"
	Bimbila	Wulensi	Gari/kokonte making

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
	Kete-Krachi	Borae No.2	"
	South Tougu	Agave Afedome	"
		Larve	"
		Fieve	"
		Sogakope	"
	North Tougu	Avetsi	"
		Mafi-Kumase	Agbelima/Kokonte/ Gari making
	Anlo	Mafi-Deveme	Tapioca/Agbelima Starch Biscuits making

REGION	DISTRICT	PROCESSING UNIT/ LOCATION	TYPE OF ACTIVITY
Northern	Damongo	Achubunyo	Gari Making
		Kanato	Kokonte/ Gari Making
		Laribanga	"
		Soalepe	"
		Damongo Town	"
		Kpandai Women Gp.	Gari Making
		Mankango	Kokonte/ Gari making
		Katejeli	"
		Kubaimata	"
		Kubiamata	"
		Kanbonwule	"
	Bimbila	Wulensi	
		Gari/kokonte making	

Annex 5

DIAGRAMS OF SOME LOCALLY-PRODUCED EQUIPMENT USED IN ROOT AND TUBER CROPS PROCESSING

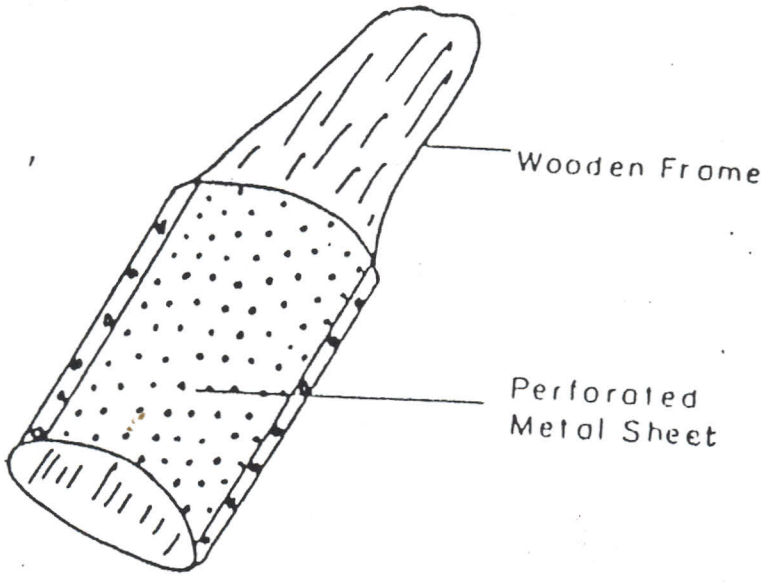


Fig. Hand-held grater (Traditional)

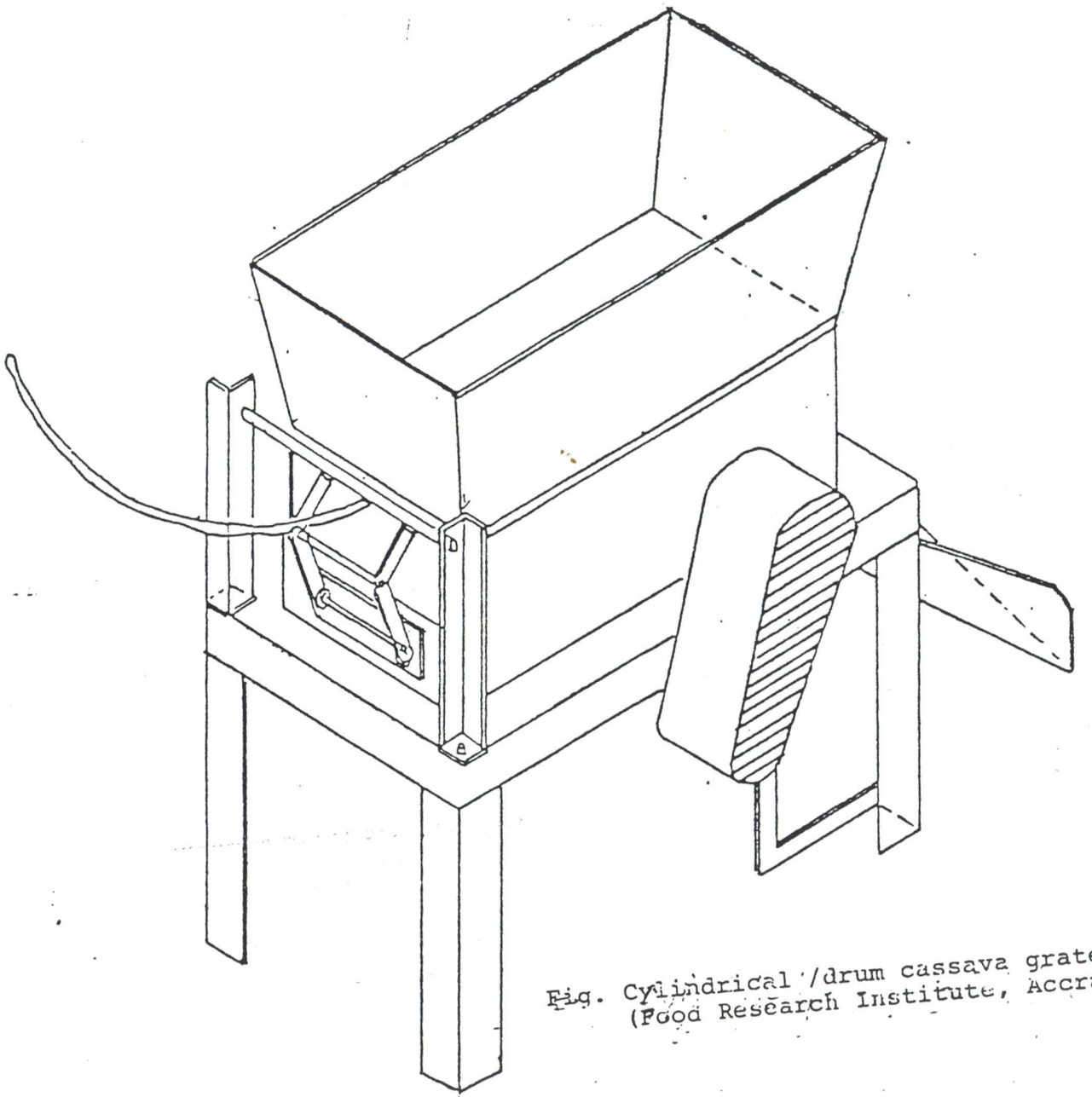


Fig. Cylindrical /drum cassava grater
(Food Research Institute, Accra)

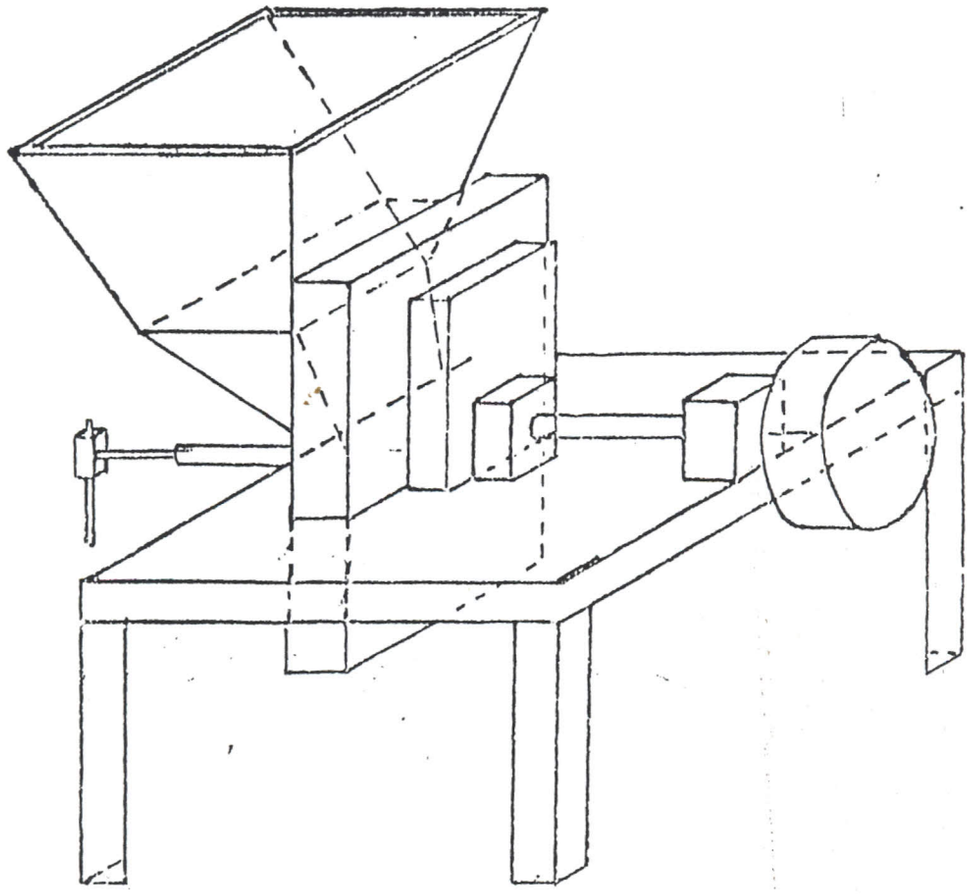


Fig. Circular disc cassava grater
(Vertical acting)

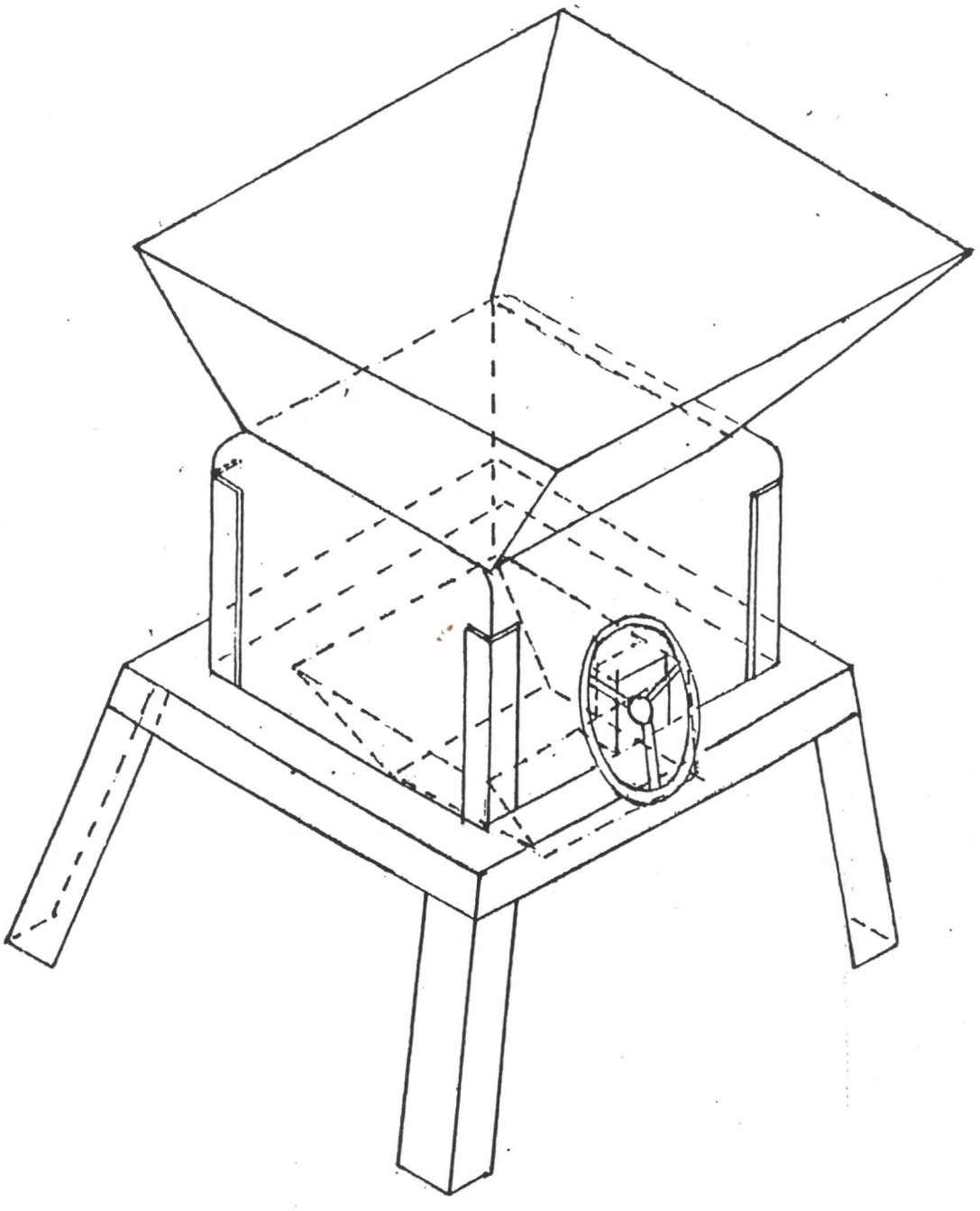


Fig. Cylindrical/drum cassava grater

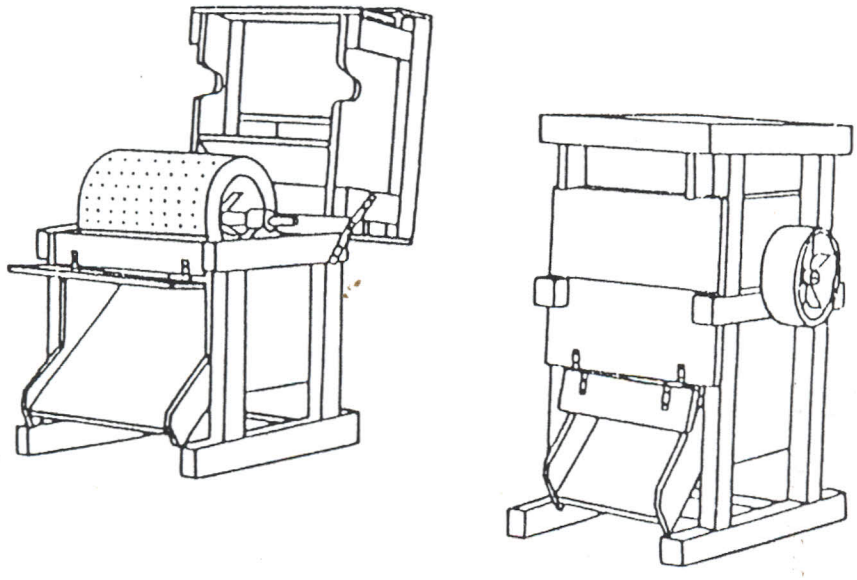


Fig. Cylindrical/drum cassava grater with wooden frame
(Agricultural Engineering Dept., UST, Kumasi)

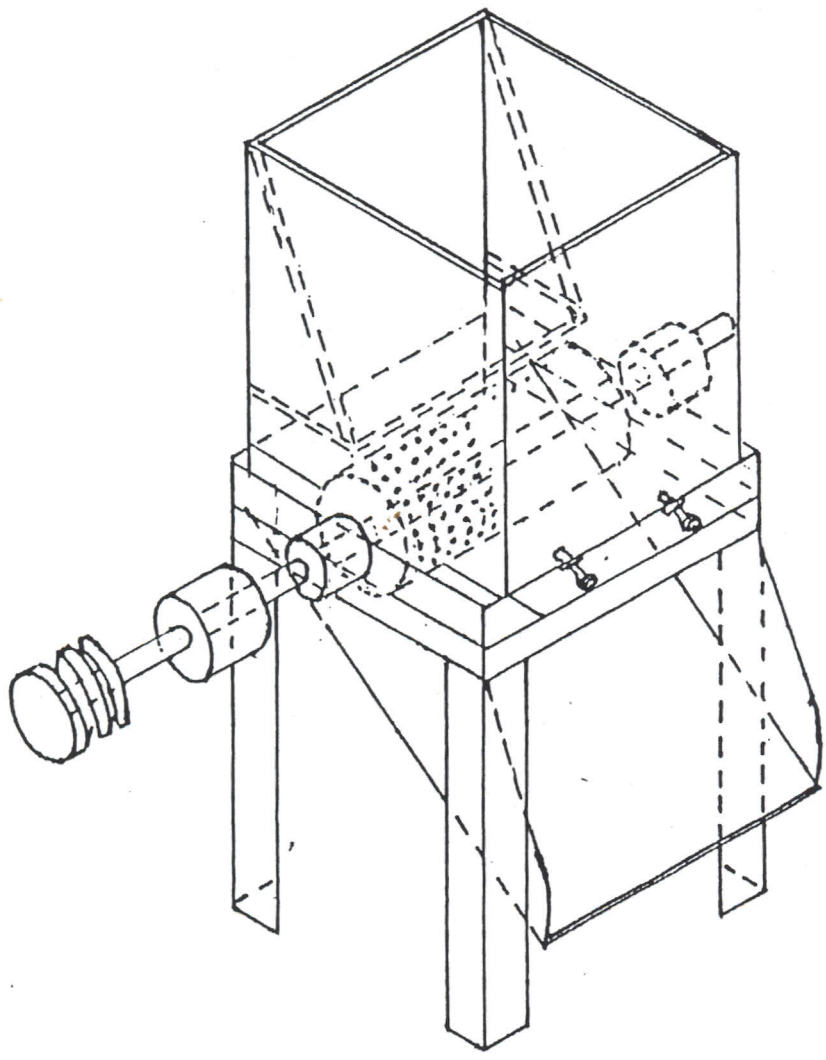


Fig. Cylindrical/drum cassava grater with wooden hopper
(Food Research Institute, Accra)

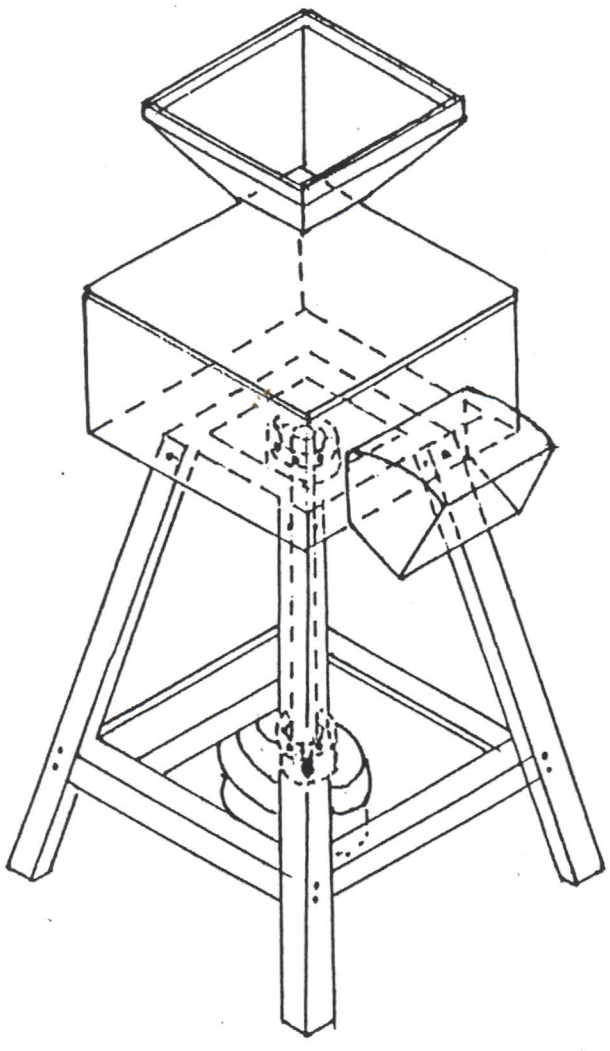


Fig Circular disc cassava grater
(Agricultural Engineers Ltd., Accra)

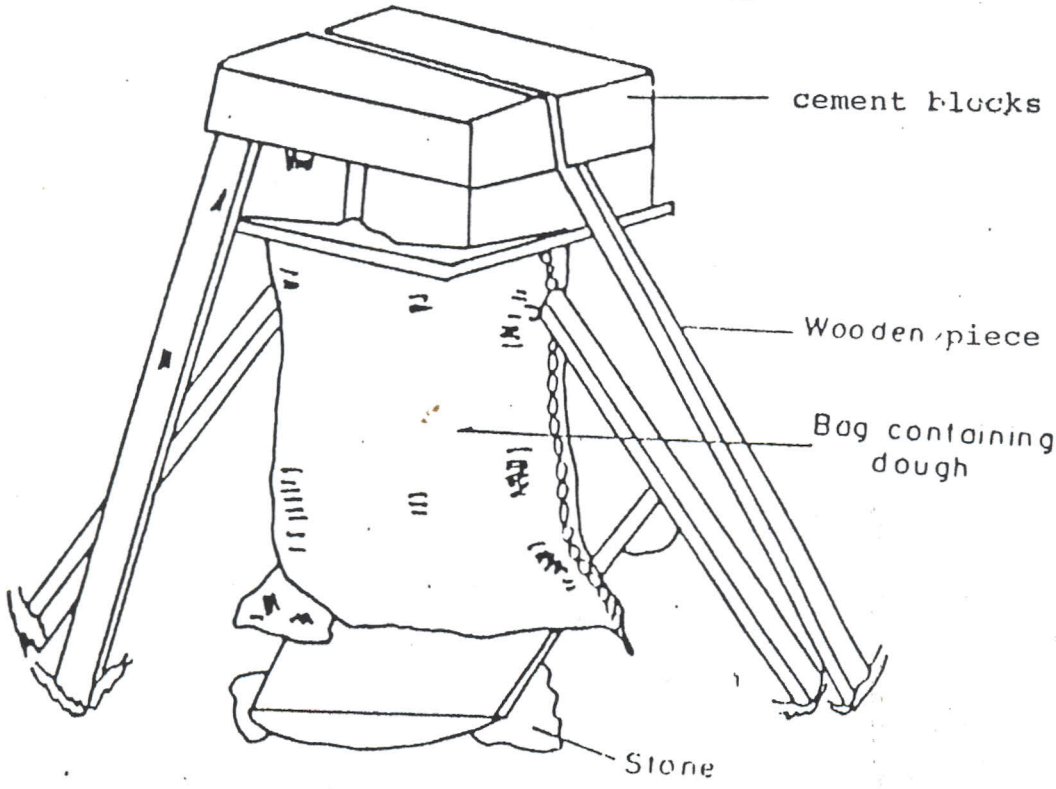


Fig. Cassava press (traditional)

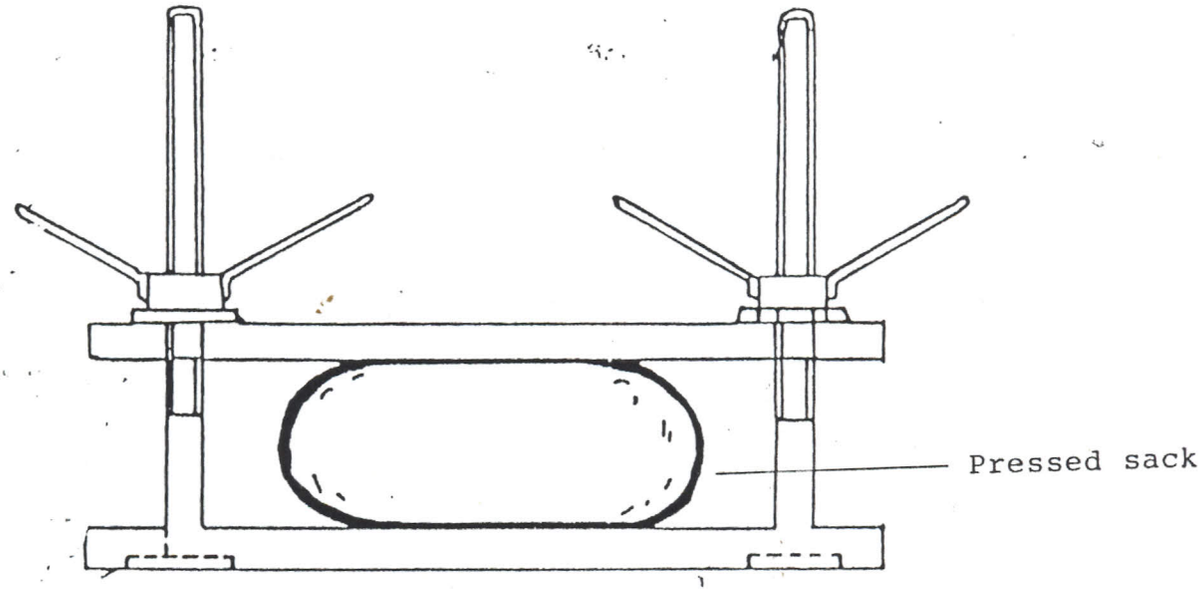


Fig. Cassava screw press

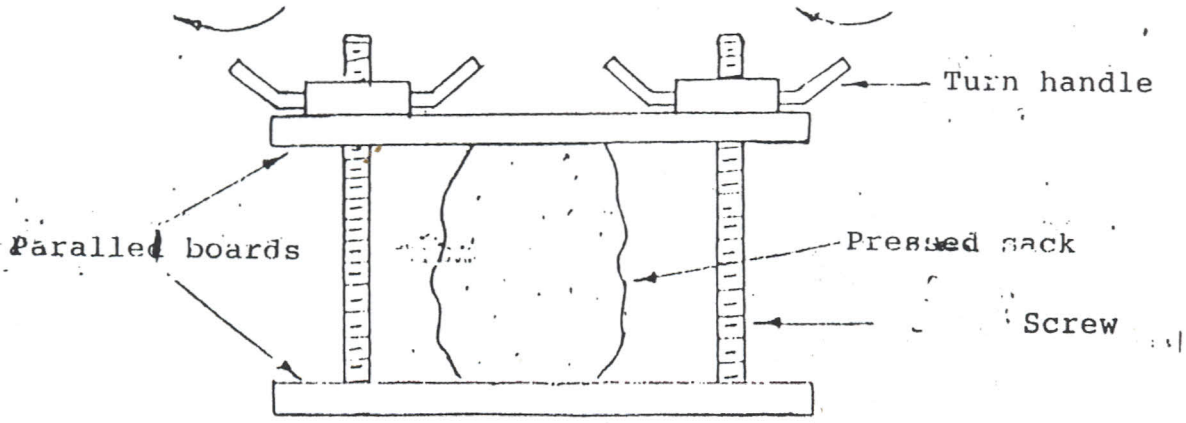


Fig. Parallel board cassava press

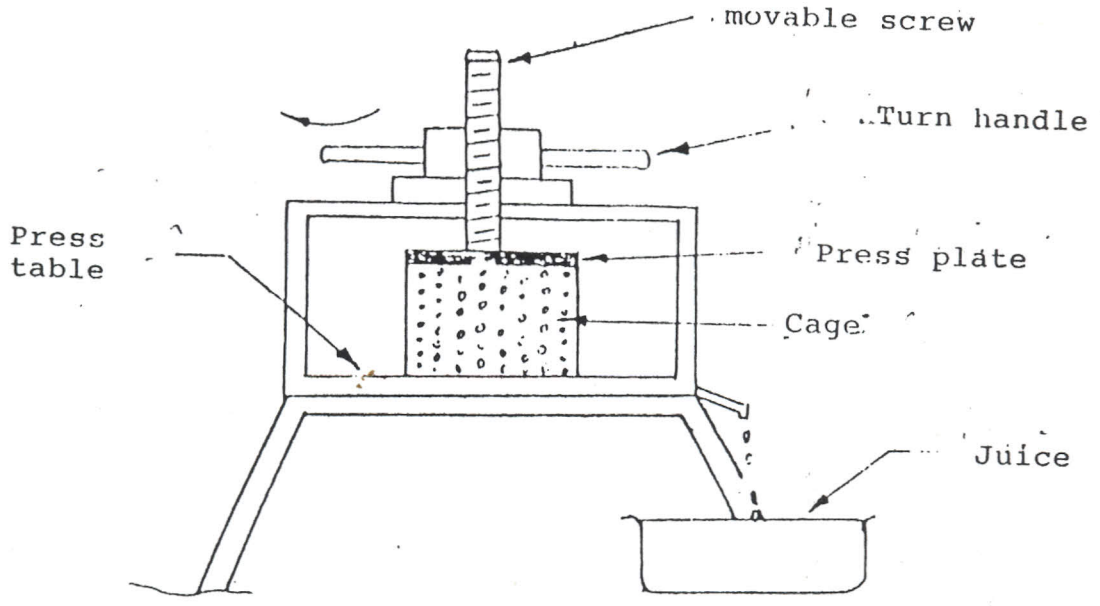


Fig. Cassava screw-cum plate press

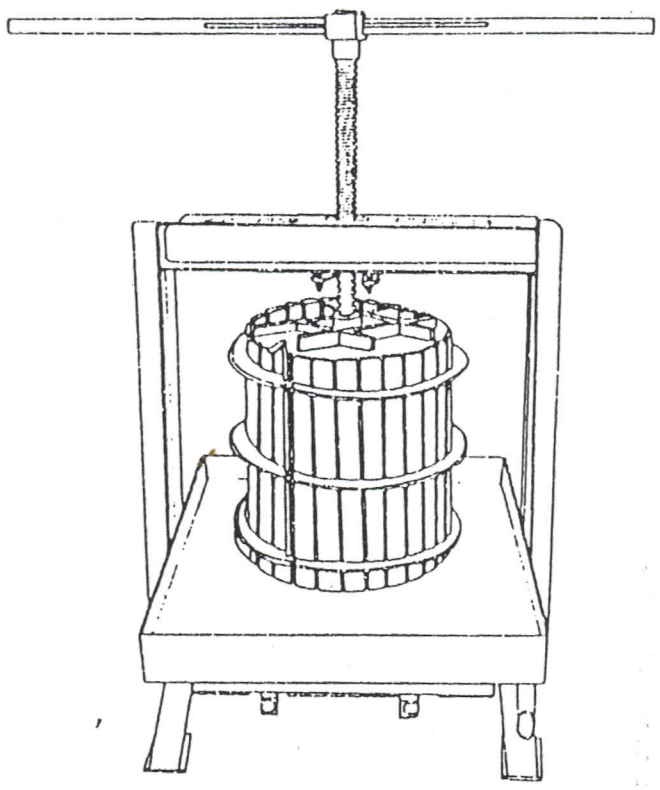


Fig. Cage or basket cassava screw press

(Agricultural Engineering Dept., UST, Kumasi)

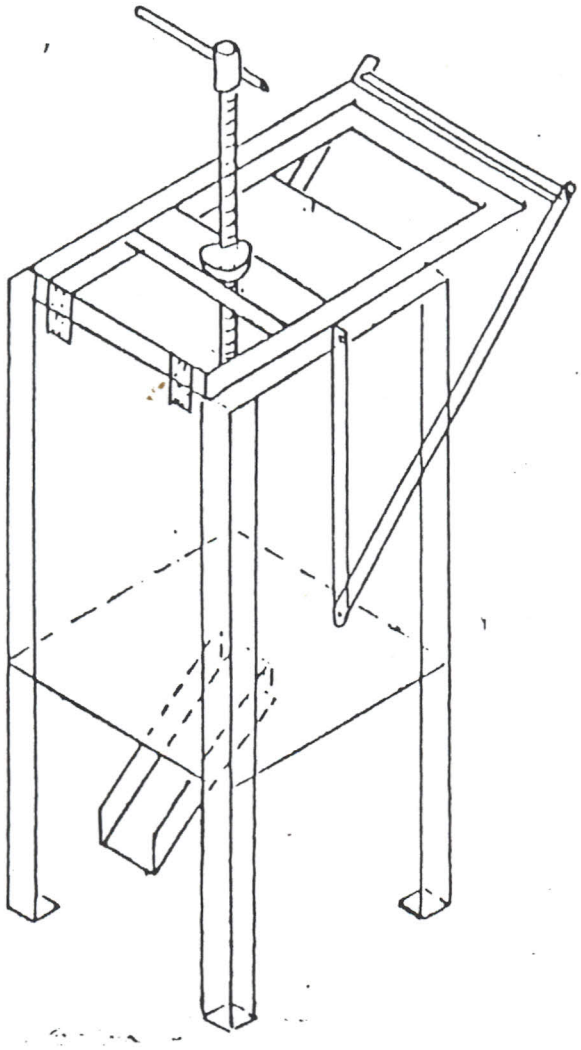


Fig Cassava screw-cum plate press with housing unit
(Food Research Institute, Accra)

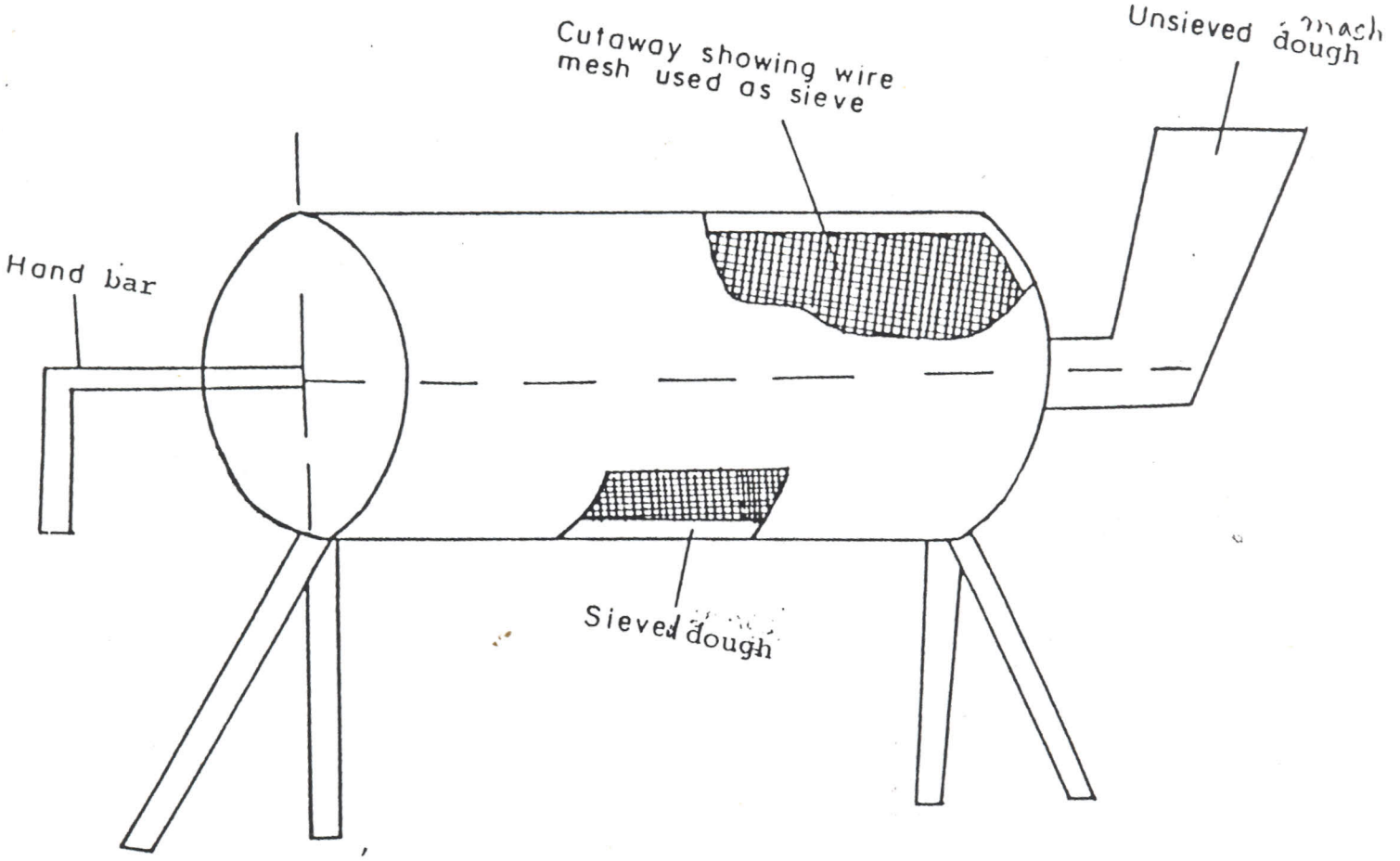


Fig. Hand-operated roasting drum sieve
(SIS Engineering Ltd., Kumasi)

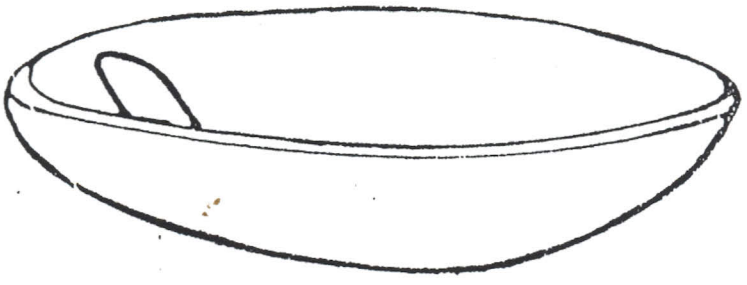


Fig. Gari Roasting Pan
(Traditional)

Fig. Woodenstirrer for roasting

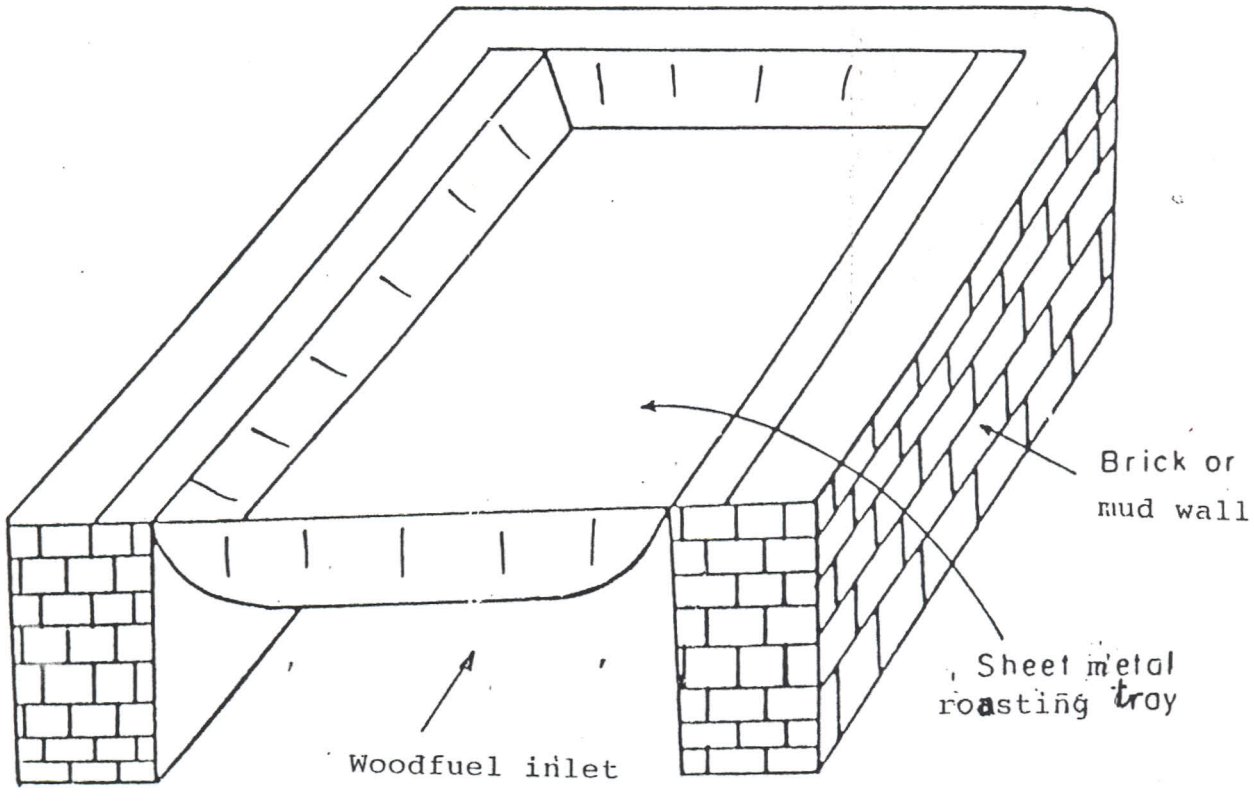


Fig Gari roasting unit
(Agbenskod Engineering Co. Ltd, Accra)

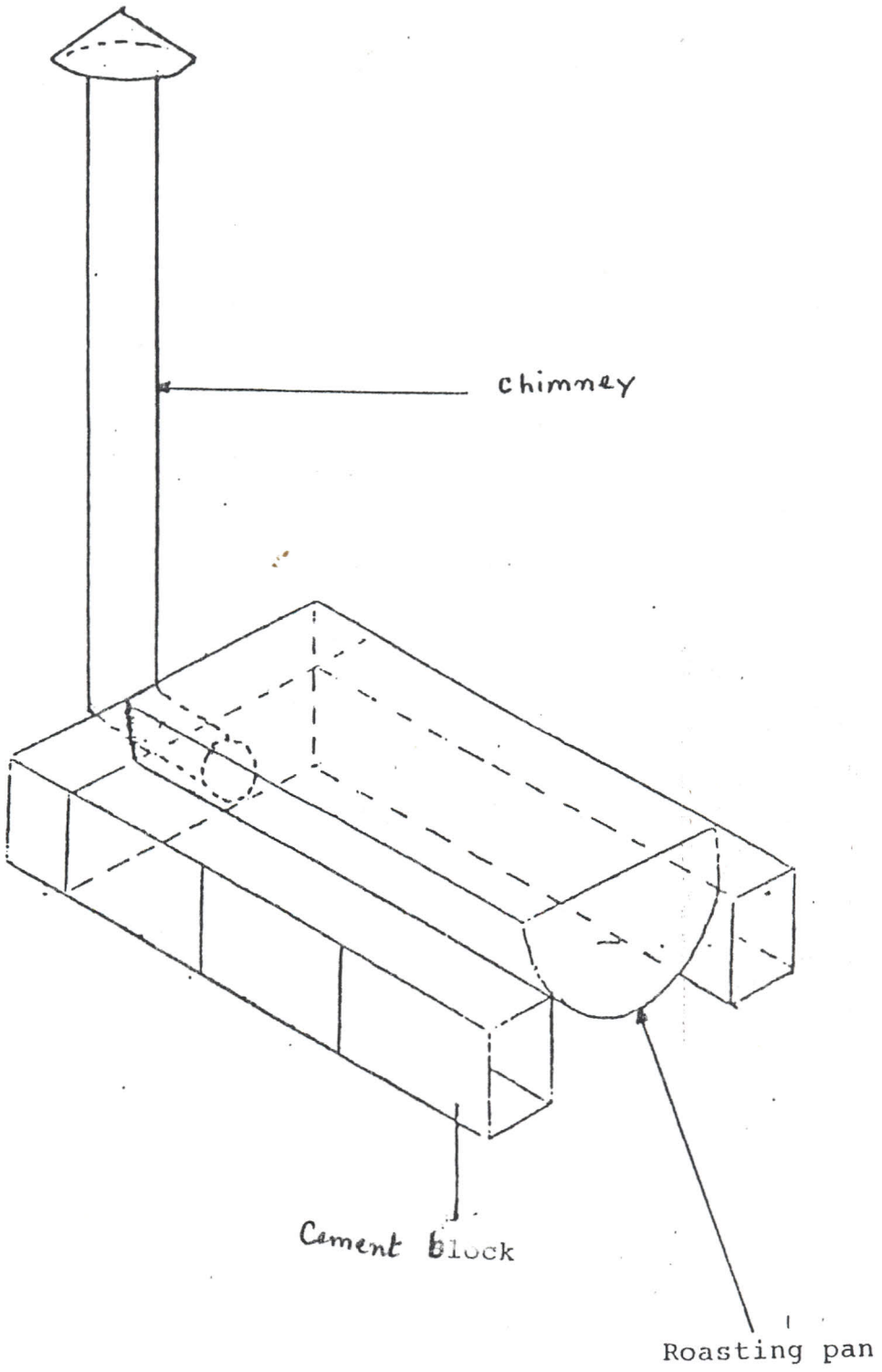


Fig. Gari roasting unit

(Agricultural Engineers Ltd., Accra).

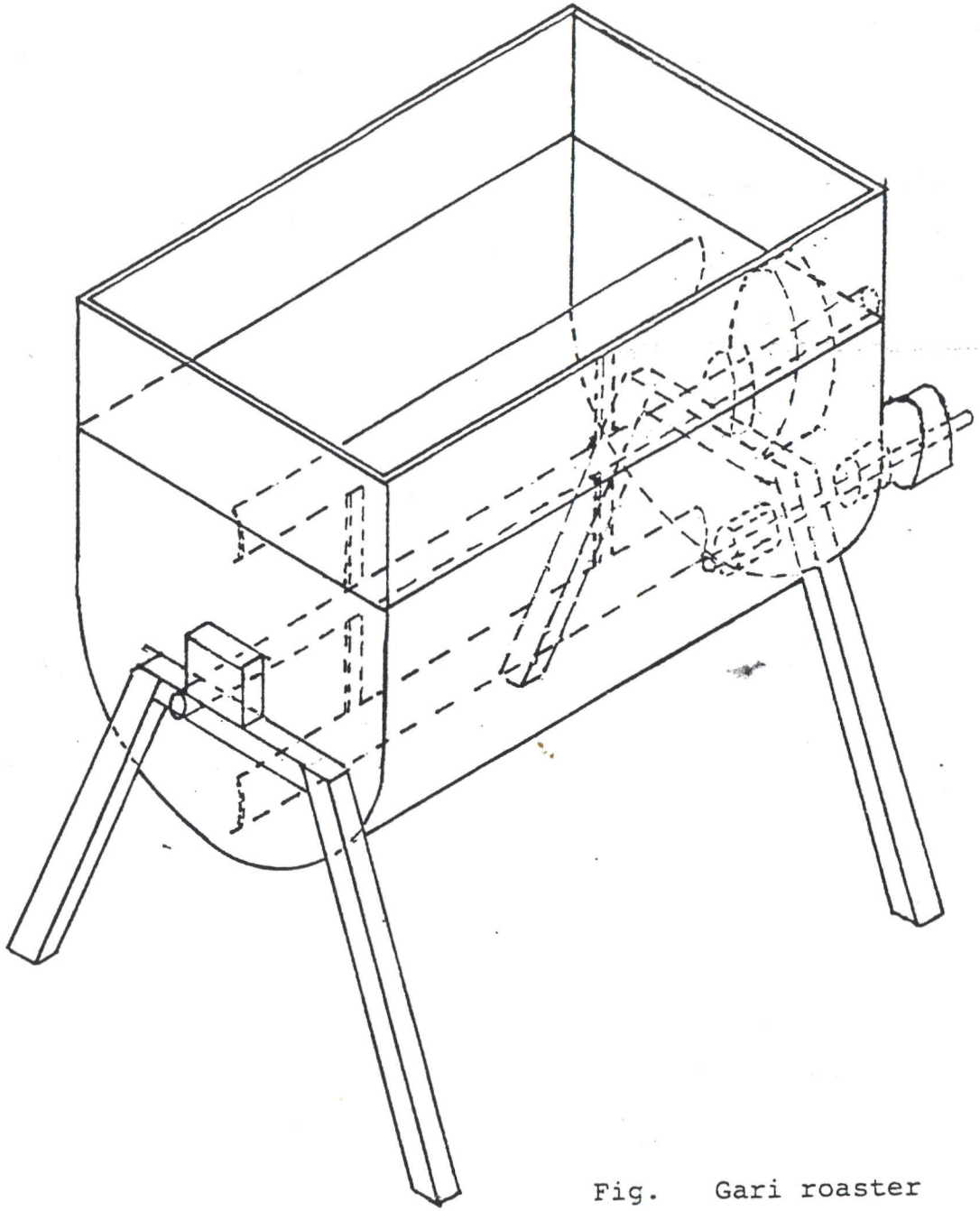


Fig. Gari roaster

(SIS Engineering Ltd, Kumasi)

Annex 6

MANUFACTURERS

OF

LOCALLY-PRODUCED EQUIPMENT USED IN ROOT AND TUBER CROPS PROCESSING

Equipment	Producer(s)	Specifications/ Characteristics	Use/Remarks
I. Cassava grater . Cylindrical/ drum type	. Agbemskod Engineering Ltd., Accra.	Power 6kw Diesel or electric motor	for grating cassava
	. Hormeku Engineering Works Ltd., Ashiaman	Power 4-6 kw Diesel or electric motor	"
	. SIS Engineering Ltd., Kumasi.	Power 6kw Diesel or electric motor	"
	. Department of Agricultural Engineering. UST.	Length : 2050mm width: 1050mm Height: 1550mm Power: 7.5-11kw Capacity: 55-750kg/hr.	"
	. Danmens Mechanical Engineering Ltd., Takoradi.	Power: 6kw Diesel or electric motor	"
	. Agba Mechanical Engineering Works Takoradi	Power: 6kw Diesel or electric motor	"
	. Metal & Motors Eng. Co. Ltd.,Accra.	Power: 4kw Diesel or Electric motor	"
	. Food Research Institute Accra	Power: 4-6kw Diesel or electric motor	

LOCALLY-PRODUCED EQUIPMENT USED IN ROOT AND TUBER CROPS PROCESSING

Equipment	Producer(s)	Specifications/ Characteristics	Use/Remarks
I. Cassava grater . Cylindrical/ drum type	. Agbemskod Engineering Ltd., Accra.	Power 6kw Diesel or electric motor	for grating cassava
	. Hormeku Engineering Works Ltd., Ashiaman	Power 4-6 kw Diesel or electric motor	"
	. SIS Engineering Ltd.. Kumasi.	Power 6kw Diesel or electric motor	"
	. Department of Agricultural Engineering. UST.	Length : 2050mm width: 1050mm Height: 1550mm Power: 7.5-11kw Capacity: 55-750kg/hr.	"
	. Danmens Mechanical Engineering Ltd., Takoradi.	Power: 6kw Diesel or electric motor	"
	. Agba Mechanical Engineering Works Takoradi	Power: 6kw Diesel or electric motor	"
	. Metal & Motors Eng. Co. Ltd..Accra.	Power: 4kw Diesel or Electric motor	"
	. Food Research Institute Accra	Power: 4-6kw Diesel or electric motor	

	. Desiadenyo Welding Shop, Ho	Power: 6kw Diesel or electric motor	For grating cassava
	. City Welding and Trading Enterprise, Ho	Power: 6kw Diesel or electric motor concave dish pressusre plate.	"
	. Otutey Tettehfio Sege	Power: 6kw Diesel or electric motor Wooden hopper	"
	. Numo Tei Joe Kaseh, Ada	Power" 6kw Diesel or electric motor Wooden hopper	
Circular disc type	. Agricultural Engineers Ltd., Accra.	Power: 3.7kw Diesel or electric motor Capacity: 125kg/hr	

II. Cassava Screw Press

. Parallel Board Type	.SIS Engineering Ltd., Kumasi	Power: Manual output	For extracting juice from grated cassava
Steel frame/ metal plate type	. Agbemskod Engineering Ltd., Accra	Power: manual	"
	Hormeku Engineering Works Ltd., Ashiaman	Power: manual	"
	Metal & Motors Engineering Co., Ltd., Accra		

	. Desiadenyo Welding Shop, Ho	Power: 8kw Diesel or electric motor	For grating cassava
	. City Welding and Trading Enterprise, Ho	Power: 8kw Diesel or electric motor concave dish pressware plate.	"
	. Otutey Tettehfio Sege	Power: 8kw Diesel or electric motor Wooden hopper	"
	. Numo Tei Joe Hasel. Ada	Power" 8kw Diesel or electric motor Wooden hopper	
Circular disc type	. Agricultural Engineers Ltd., Accra.	Power: 8.7kw Diesel or electric motor Capacity: 125kg/hr	

II. Cassava Screw Press

. Parallel Board Type	.SIS Engineering Ltd., Kumasi	Power: Manual output	For extracting juice from grated cassava
Steel frame/ metal plate type	. Agbemskod Engineering Ltd., Accra	Power: manual	"
	Hormeku Engineering Works Ltd., Ashiaman	Power: manual	"
	Metal & Motors Engineering Co., Ltd., Accra		

Steel frame/ cage type	Department of Agri-cultural Engineering UST	Major external diameters 74mm. Minor external diameters 60mm capacity: 45-55kg/hr Power: 2 person	"
Steel frame/ steel frame housing	Food Research Institute Accra.	Power: manual, 1 person Capacity; 70kg per charge	"
Hydraulic type	Agricultural Engineers Ltd., Accra.	Power: Manual	
III Gari roaster . without chimney	. SIS Engineering Ltd., Kumasi.	Power: Diesel engine wood fuel, Output: 240kg/hr	For roasting cassava dough into gari
	. Industrial Research Institute, Accra	Capacity: 8kg per batch of 15 mins. Motor speed: 1440 rpm Motor rating: 2.2kw Rotation of drum: 30rmp.	
.With chimney	.Agricultural Engineers Ltd., Accra	Heated trough Manual stirring	

	Steel frame/ cage type	Department of Agri-cultural Engineering UST	Major external diameters 74mm. Minor external diameters 60mm capacity: 45-55kg/hr Power: 2 person	"
	Steel frame/ steel frame housing	Food Research Institute Accra.	Power: manual, 1 person Capacity: 70kg per charge	"
	Hydraulic type	Agricultural Engineers Ltd., Accra.	Power: Manual	"
III	Gari roaster			
	. without chimney	. SIS Engineering Ltd., Kumasi.	Power: Diesel engine wood fuel, Output: 240kg/hr	For roasting cassava dough into gari
		. Industrial Research Institute, Accra	Capacity: 8kg per batch of 15 mins. Motor speed: 1440 rpm Motor rating: 2.2kw Rotation of drum: 30rmp.	
	.With chimney	.Agricultural Engineers Ltd., Accra	Heated trough Manual stirring	"

Annex 7

Criteria for Assessment of Cassava Varieties

1. Morphological characteristics of the varieties.

2. Evidence of field performance

   (a) How variety fits in the farming systems.

   (b) How the variety fits in the target zones.

   (c) Yield

      (i) Data on, 2 cropping years on station and 2 cropping years on-farm (making 4 cropping years).

      (ii) Data from 5-10 locations in the major agroecological zones.

      (iii) Data with respect to wet and dry matter.

   (d) Reaction to major pest.

   (e) Reaction to major diseases.

   (f) Storage/sprouting of the planting materials.

3. Evidence of consumer acceptance

   (a) Food (fufu/ampesi, agbelima, gari, kokonte, etc.)

   (b) Industrial uses (starch, glue, glucose, etc.)

   (c) Animal feed (root, peels, leaves, etc.)

   (d) Safe HCN levels.

4. Biochemical properties

   (a) HCN content

   (b) Nature of starch

   (c) Fibre content.

5. Socio-economic data

   (a) Marginal rate of returns

   (b) Urgency for release

   (c) General advantage.

Data presented by researchers on the Four new cassava varieties and Local Ankra serving as control.

Annex 8

METHODOLOGY FOR THE TRANSFER OF CASSAVA STORAGE TECHNOLOGY

In order to facilitate the technology transfer, a methodology needs to be mapped out.

In this regard consideration should be given to the following:

1. Harvesting - when to harvest and how to the harvest
2. Sorting and grading of the harvested roots
3. Transporting of sorted and grated roots
4. Storage - in baskets, wooden crates and underground.

Harvesting

When to harvest

Harvesting should be done when the roots are fully mature and in relatively dry weather to facilitate removal of adhering soil particles. Depending upon the variety the cassava should therefore be harvested between 6-7 months, 9-10 month, or 12-13 month for the 6-month, 9-month, and 12-month variety respectively.

Early harvesting of the cassava roots, results in low yields and poor eating qualities.

Late harvesting of the roots exposes them to pests attack, makes them woody and fibrous and ties land unnecessary to one crop.

The roots should not be harvested soon after rains or when the soil is too wet. At this time the roots have a high moisture content which makes them difficult to store and would have sticking on them wet soil particles (especially if the soil is clayed) making the roots difficulty to clean.

How to harvest

The cassava roots should be uprooted by carefully loosening the soil around them by means of a cutlass or preferably a wooden tool to reduce root damage. Next slowly pull the plant avoiding dragging the roots to prevent bruises and cuts which may lead to early deterioration of the roots.

In separating the roots from the stem use a sharp cutlass or knife and cut each root as close as possible to the stem. The individual roots should not be broken off because this method can also cause root damage.

After harvesting the roots should be kept in a cool shady place such as a tree and should not left in the sun as too much heat causes high weight loss and early deterioration.

Sorting

Damaged roots should be separated from undamaged ones, and the small ones from the big ones. The damaged roots should not be stored because they would deteriorate. They are to be used at once. The small ones are also to be used.

Transporting sorted and graded roots

The roots should be transported from the field to the storage area in baskets suitably lined with leaves and capable of holding 30-50kg of roots. The filled baskets should be handled with care. If possible jute sacks should not be used for transporting the roots as there is always the tendency for the roots to get bruised or damaged.

Storage

The undamaged roots can be stored in (1) baskets, (2) wooden crates, and (3) soil (underground).

Storage in baskets

Baskets to be used in the storage of the roots may be lined with plantain leaves or other suitable leaves. The roots may also be cured in moist wood ash for two days before storing.

The following procedures may be followed in the storage method:

1. Measure a quantity of saw dust, or wood shavings into a metal container.
2. Add water, by sprinkling, equivalent to one-half of the weight of the saw dust or wood shavings.
3. Mix thoroughly after each sprinkling, to obtain a 50 per cent moisture content.
4. Place 3cm thick of the moist medium at the bottom of the basket. Preferably the bottom of the basket and the sides can be lined with suitable green leaves.
5. Arrange in alternate layers cassava and 1.5cm thick moist medium until the basket is nearly full.
6. Cover the topmost layer of the roots with 9cm thick moist medium.
7. To prevent surface desiccation, the top of the medium may be covered with suitable green leaves.
8. Keep the filled baskets in a dry cool ventilated place.

Storage in Wooden crates

Any size of wooden crate can be used to store small quantities of cassava roots. A crate 45.7cm (1.5ft) wide, 61cm (2.0ft) long and 30.5cm (1.0ft) deep can accommodate about 20kg cassava packed in moist sand or moist saw dust. Each crate should have a wooden cover.

The following procedure may be followed:

1. Obtain 50 per cent moist sand or moist sawdust using 1-3 as in basket storage method.
2. Line the crate first with newsprint or newspaper.

3. Line the bottom of the crate with 3cm thick of the moist medium.
4. Arrange in alternative layers cassava and 1.5cm thick moist medium until the crate is nearly full.
5. Cover the topmost layer of the roots with 9cm. thick moist medium.
6. Cover the crate with its wooden cover.
7. Keep the filled crates in a dry cool, well ventilated place such as a bamboo shed with thatched roof.
8. In the storage shed the filled crates should be placed on 20cm. high raised platform made of wood or bamboo and which can support their weight. The crates should be arranged in such a way as to allow enough air to circulate around them.

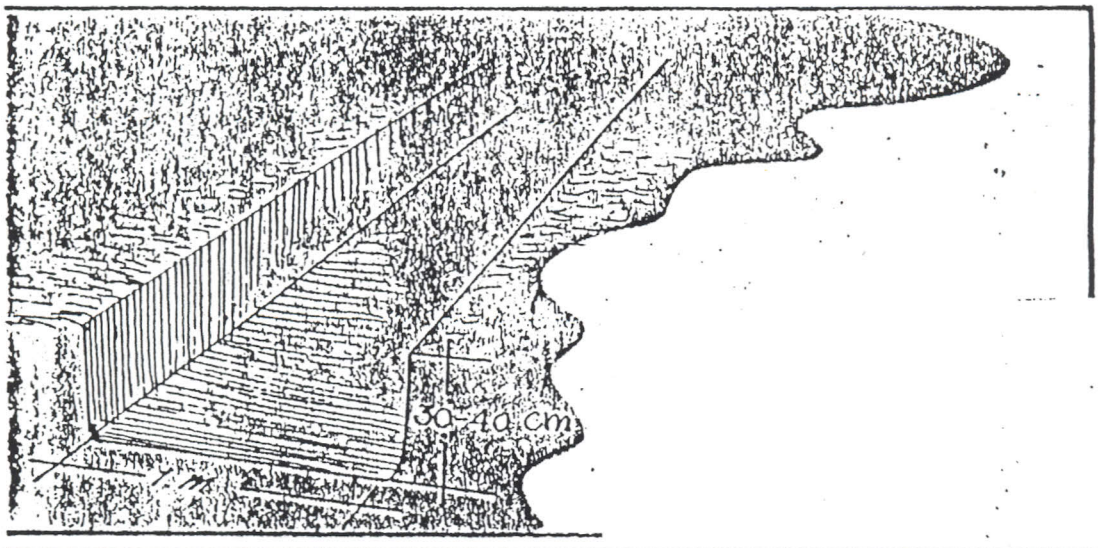
Storage in Soil

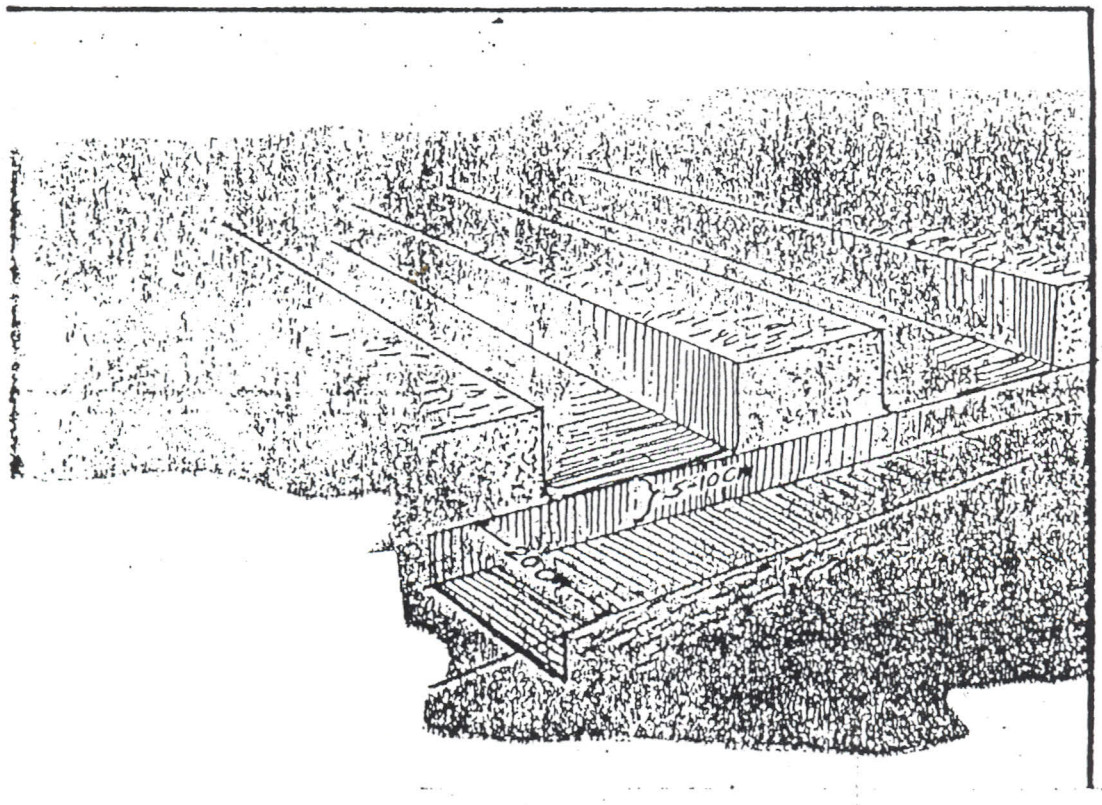
The following procedure may be followed:

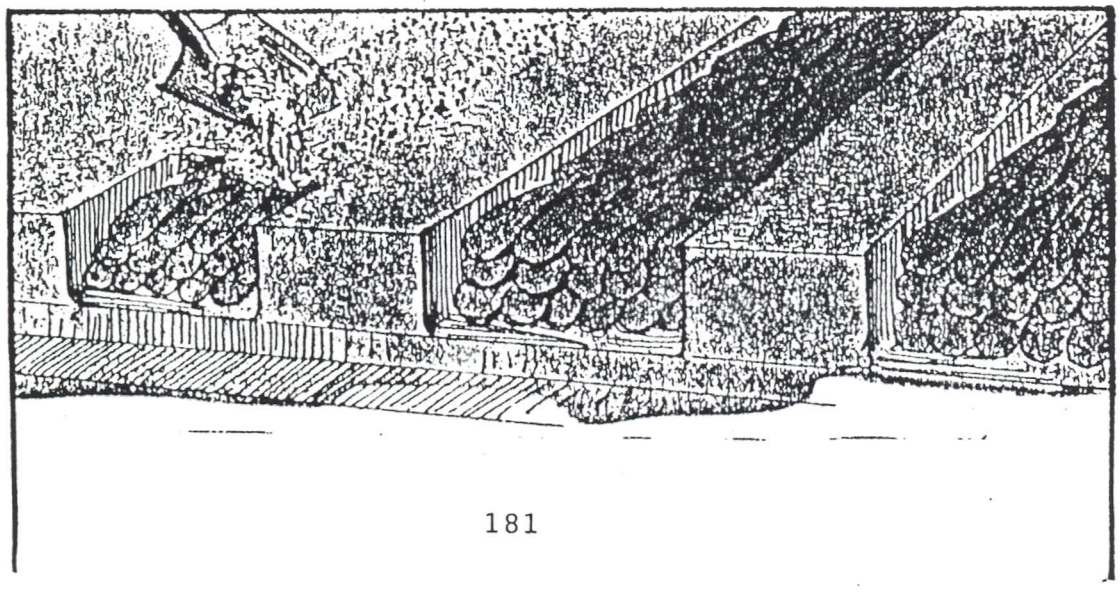
1. Select a suitable storage site which should be well-drained, preferably shaded and slightly sloping.
2. In the selected are dig trenches measuring 1m wide and 30-40cm. deep as shown in Fig.1. Dig the trenches in such a way that their lengths will be running down hill. At the lower end of the trench make.

a. Drainage channel which should be at least 20cm wide and 5-10cm deeper than the storage trench as in Fig.2. Vary the length of the trench according to the quantity of roots to be stored.

3. Arrange mature, undamaged cassava roots inside the trenches. Cover each layer of roots with soil preferably river sand or seasand. Clay loam may be used if it is not too wet. On no account should you use heavy wet clay to cover the roots because this type of soil could just enhance deterioration.


30-40 cm


5-10 cm
20 cm



Annex 9

*BUILDING AN IMPROVED DRYING AND STORAGE CRIB

METHOD I

CAPACITY, LOAD AND CORRESPONDING FIELD AREA FOR DIFFERENT SIZE OF CRIBS

A	Crib width, m		0.6	1.0	1.5	2.0
B	Lenght of one section, m		1.6	1.6	1.6	1.6
C	Capacity for husked maize, m^3		1.3	2.2	3.3	4.5
D	Field area corresponding	500 kg/ha	0.86	1.5	2.2	2.9
E	to the drying capacity	1000 kg/ha	0.43	0.7	1.1	1.5
F	in C. Hectares for diffe-	2000 kg/ha	0.22	0.35	0.55	0.73
G	rent yields of shelled maize	3000 kg/ha	0.14	0.24	0.37	0.49
H	Weight of husked maize, 30% MC	kg per section	730	1230	1850	2520
I	Load on the corner posts	kg per corner post	280	410	560	730
J	Load on the section posts (3.2 m long crib)	kg per section post	560	820	1120	1460
K	Uniformly distributed load on one beam, Newton, N		3600	6030	9070	12360
L	Maximum external bending moment on beams, N · m		720	1206	1814	2472
			Diameter of a log (beam)			
			cm	cm	cm	cm
M	Maximum permissible tensile stress after the safety factor has been incorporated	5 N/mm^2	11.5	13.5	15.5	17.5
N		10 N/mm^2	9.0	11.0	12.5	13.5
O		15 N/mm^2	8.0	9.5	11.0	12.0
P		20 N/mm^2	7.5	8.5	10.0	11.0
Q		30 N/mm^2	6.5	7.5	8.5	9.5

Figure 7.4. Capacity, load and corresponding field area for different size of cribs.

For I and J, the weight of the structure is included by 100 kg/corner post and 200 kg/section post.

*FAO Agricultural Services Bulletin 66

Example 7.1.

Question: What is the minimum diameter of a log-beam in a 1.0 m wide and 1.6 m long crib? The log has a tensile strength of 70 N/mm^2. By introducing a safety factor of 7, the maximum permissible stress for the log is 10 N/mm^2.

From the table, Figure 7.4 line N, the minimum diameter is found to be 11 cm.

Table 7.1. Approximate soil bearing capacity

Peat	< 0.5 kg/cm^2
Soft clay (wet clay)	1 kg/cm^2
Dry sand	3 kg/cm^2
Gravel	6 kg/cm^2
Rock	8 kg/cm^2

Table 7.2. Average bending strength of timber from different tropic species.

Species	Origin	Average maximum bending strength, N/mm^2
SOFTWOODS		
Pine	South America	98
Pine, Radiata	Kenya	85
Podo	Kenya	82
HARDWOODS		
Abura	West Africa	83
Afzelia	Tanzania	97
Albizia	West Africa	105
Alstonia	Uganda	59
Araracanga	Brazil	132
Bonak	British Honduras	79
Camphor wood	Kenya	92
Iroko	West Africa	90
Mchenga	Tanzania	147
Mugongo	Zimbabwe	17
Muniga	Tanzania	94

E. List of materials

When purchasing the materials and during the erection of the crib, it is very important to note and follow the dimensions and measurements shown on the drawings and given in the description for each crib component and in Figure 7.4.

Alternatively, the crib can be constructed entirely from home grown materials, available on the farm or in nearby forests, with a pitched roof thatched with grass, papyrus of palm leaves as shown on drawings No. 9-10-11, leaving the farmer to purchase only wire and nails.

Materials

Below is a list giving the most commonly available materials and for which purpose they can be used:

Main posts:	Bamboo (unsplit) Blue gum (eucalyptus) Wattle Sawn timber Mangrove posts Cedar Any type of hardwood - rot and termite resistant for the lower main posts.
Beams:	Same as for main posts
Rafters:	" " " " "
Purlins:	" " " " "
Wall supporters:	" " " " "
Floor sticks/poles:	Same as for main posts Sisal flower stems (unsplit)
Wall sticks/poles:	Same as for main posts Sisal flower stems (unsplit and split) Bamboo (unsplit and split)
Roof:	Galvanized corrugated iron sheets Grass) High Papyrus) pitched Palm leaves (Makuti)) roof only
Rat guards:	Plain galvanized iron sheets Old tins.

Materials not listed can of course be used as alternatives to the ones listed as long as they have the same strength. A combination of the different materials is also possible. Note that all bark must be removed from the timber before being used for the crib.

LIST OF MATERIALS FOR ERECTION OF A TWO-SECTION (3.2 m long) RECTANGULAR CRIB

STRUCTURAL COMPONENTS	Dimensioning or quality	0.6 m Crib Nos.	0.6 m Crib Length m	1.0 m Crib Nos.	1.0 m Crib Length m	1.5 m Crib Nos.	1.5 m Crib Length m	2.0 m Crib Nos.	2.0 m Crib Length m	Total Qty.	Total Price
Lower mainposts	min Ø 12 cm	-	-	-	-	-	-	6	1.60		
Beams	see fig.24	-	-	-	-	-	-	2	3.50		
Upper main posts, front	min Ø 10 cm	-	-	-	-	-	-	6	2.20		
- - - , rear	-	-	-	-	-	-	-	6	1.75		
Rafters	min Ø 8 cm	-	-	-	-	-	-	3	2.10		
Purlins	min Ø 6 cm	-	-	-	-	-	-	2	4.00		
Wall supporters, facade	min Ø 5 cm	-	-	-	-	-	-	5	3.50		
- - , gables	-	2	0.80	2	1.2	2	1.70	2	2.20		
Wall diagonals, facade	-	-	-	-	-	-	-	4	2.50		
- - , gables	-	2	0.85	2	1.4	2	2.20	2	2.80		
Roof diagonals	-	2	2.10	2	2.3	2	2.60	2	2.30		
Floor sticks	min Ø 5 cm	31	0.95	31	1.35	31	1.85	31	2.35		
Wall sticks, front	-	-	-	-	-	-	-	58	2.20		
- - , rear	-	-	-	-	-	-	-	58	1.75		
- - , gables	-	22	2.30	36	2.30	54	2.30	72	2.30		
Corr. roofing sheets	gauge 30	7	1.6	7	2.0	7	2.5	7	3.0		
Galvanized plain wire	gauge 10	-	-	-	-	-	-	-	13.5		
3" nails, kg										5	
4" nails, kg										1	
5" nails, kg										1	
1" staples, kg										0.5	
Nails for roofing, kg										0.5	
Wood perservative										5	
Rat guards, plain iron sh.	gauge 30							6		1.5	
Footing											

A bar (-) in the table indicates numbers or length equivalent to the 2.0 m crib

BUILDING THE CRIB

Selection of site

Before erection of the crib can take place, a suitable site has to be selected and in this connection the following points should be in mind:

The wind: Velocity and frequency of the wind is, , the most important factor for a good drying performance of the crib. Thus an ideal site is fully exposed to the wind. Furthermore, the site should be of a size that the crib can be placed with one facade facing the prevailing wind - or perpendicular to the direction from where the wind occurs when drying maize in the crib.

Insect reinfestation of the maize from the field can be reduced by erecting the crib a good distance from the fields.

Rodent control: Keep the site and nearby area free of grass, bushes, waste maize and lodging water.

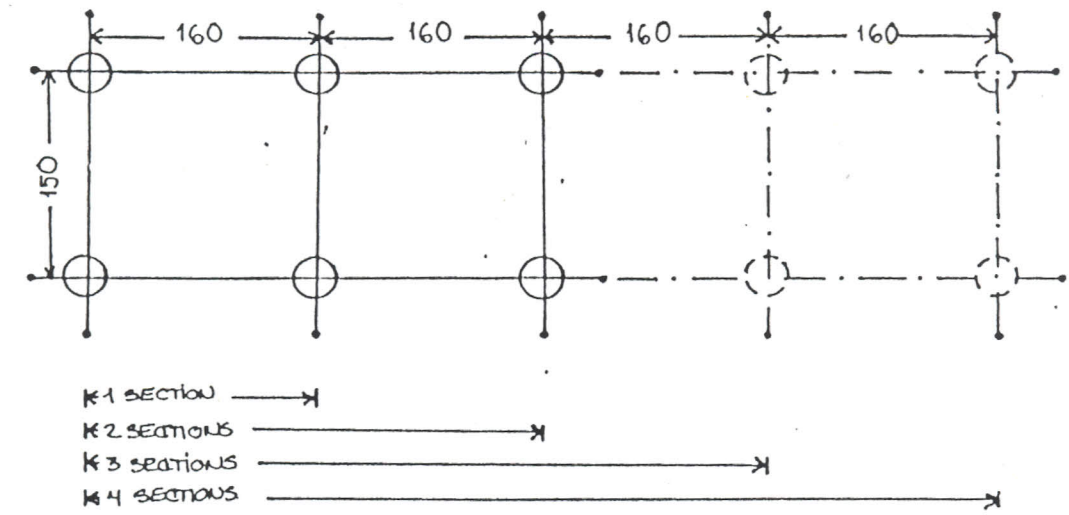
Making out the holes for the main posts: (Drawing No. 1). After selection of a suitable site, the next step is to set out the centre of the holes for the main posts. One way to mark out the centre points is with strings suspended between wooden pegs hammered into the ground and is shown in perspective on drawing No. 1. The centre points are marked with wooden pegs hammered into the ground just under where the strings cross each other. The strings are then removed and the circumference of the holes, diameter minimum 30 cm, can be marked on the ground with the pegs as centre points.

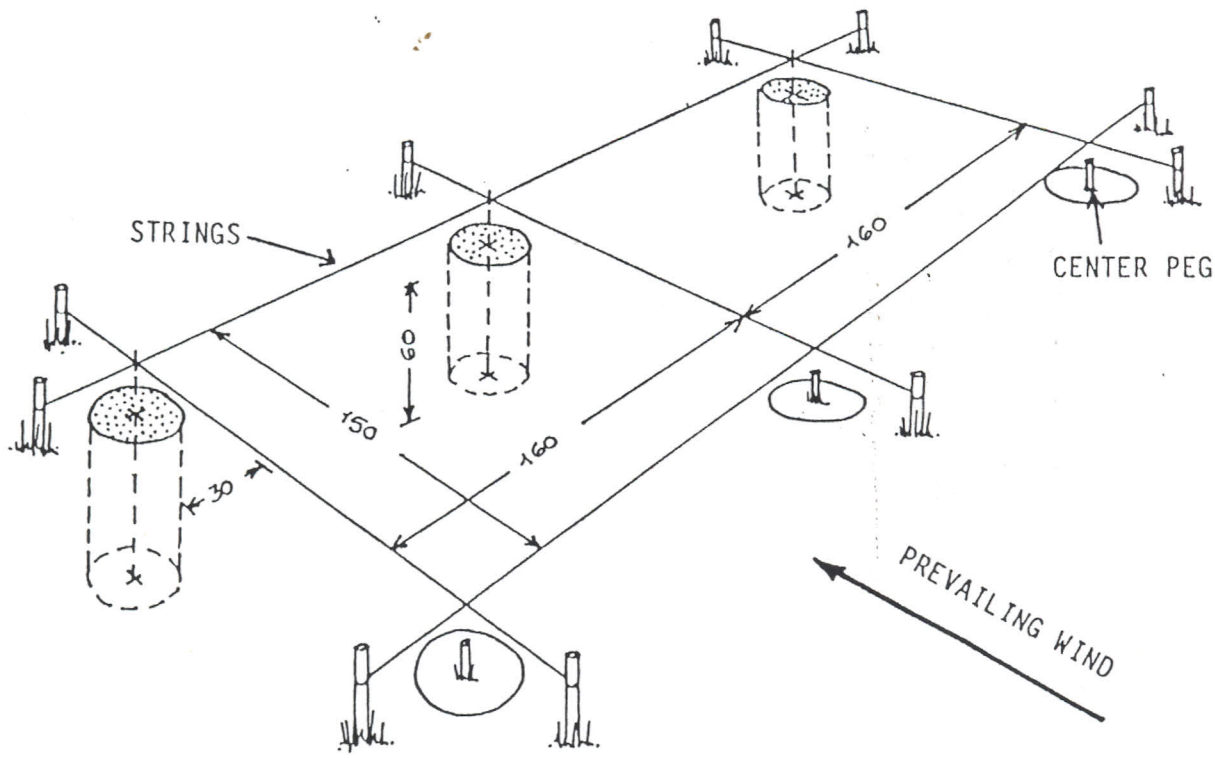
Digging the holes: Following the marks the holes are dug out to a depth of minimum 60 cm in good soil, high load bearing strengths, and 70 cm in soft soil, low bearing strengths. If the soil condition allows it the sides of the holes should be vertical.

Footing: The soil bearing capacity and the corresponding footing area may be verified from the data in Figure 7.4 and Table 7.1. The load bearing area must be enlarged either by placing a big flat stone in the bottom of the hole or casting a concrete slab, ratio 1:4:6.

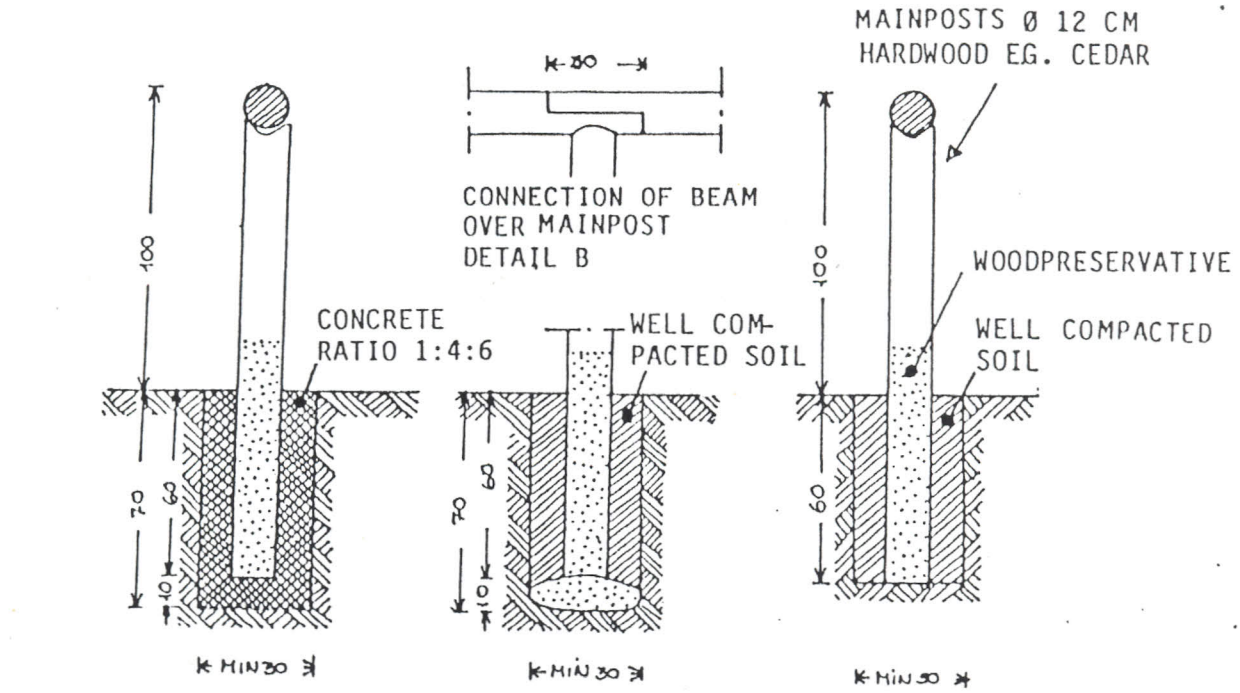
Erection of the main frame

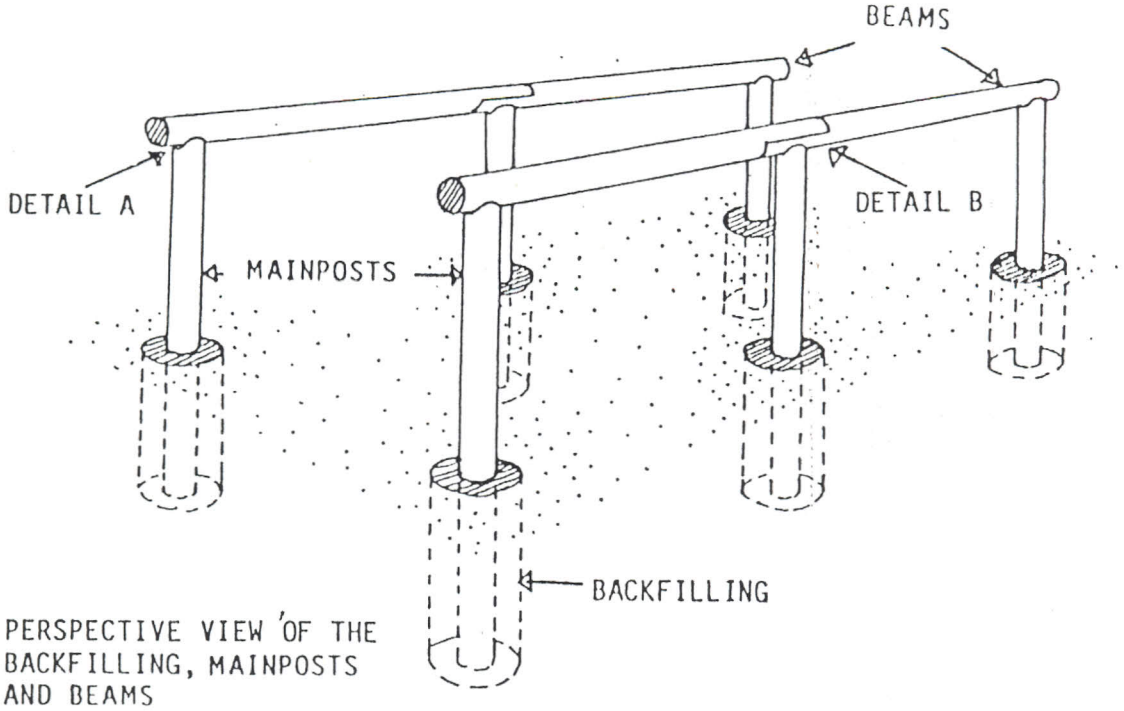
By dividing the main posts into a lower and an upper part, it is possible to use rot and termite resistant hard wood for the lower main posts which often are difficult or very costly to obtain in long lengths. Any available type of wood can be utilized for the upper part.





Drawing No. 1. Marking out the holes for the main posts of a 150 cm wide crib in 2 sections. All measures in cm.





Drawing No. 2. Erection of main posts and beams of a 150 cm wide crib in 2 sections. All measures in cm.

Impregnation: Two coats of wood preservative should be applied to the part of the posts which are going to be placed into the ground even if rot and termite resistant hard wood is used, By admixing the wood preservative and the soil used for backfilling with a chemical suitable for termite control, a higher level of protection can be obtained.

Erection of the lower main posts: (Drawing No. 2). When placing the posts, great care should be taken to ensure that the posts are in line, centred in the holes and the distance from the posts to the sides of the holes should be no less than 10 cm all the way round.

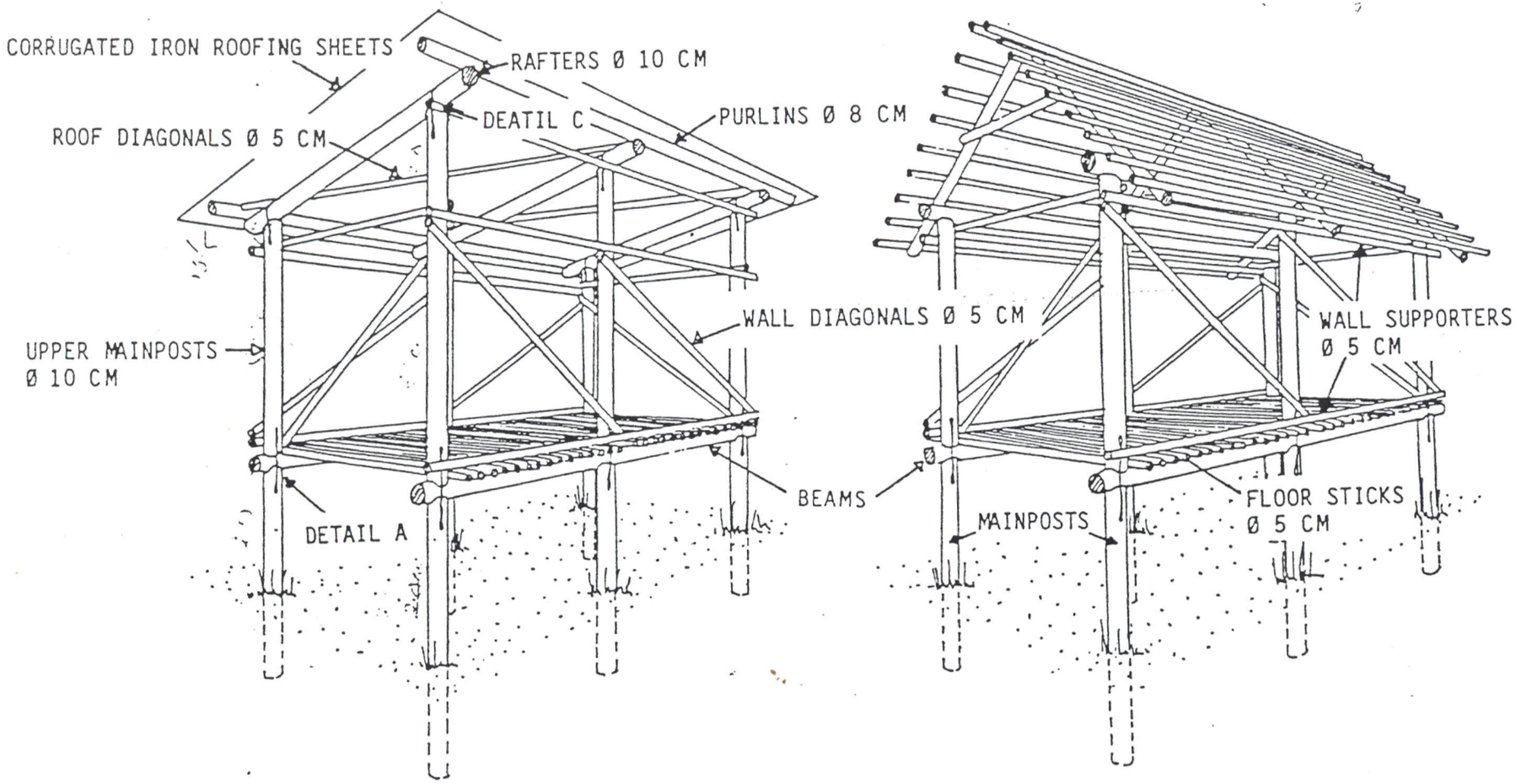
Backfilling: (Drawing No. 2). When the posts are placed in position the backfilling can take place. It should be noticed that the quality of backfilling does have a major influence on the stability of the crib, and the materials used for the backfilling should be selected according to the soil condition. In sandy or black cotton soil, concrete ratio 1:4:6 or soil cement, ratio 1:8, should be cast in the bottom of the hole and around the posts. In good soil, when the sides of the holes stand smooth and vertical, a slightly damp well graded soil without stones or lumps can be used as backfilling material. The backfilling should be placed in layers of 15 cm at a time and the soil compacted firmly in between the layers - care must be taken to ensure that the posts are kept absolutely plumb.

Beams: (Drawing No. 2). When the lower main posts are firmly placed into the ground, mark out the heights of the posts, minimum 90 cm above ground level. Note that on sloping ground, mark the height on the post on top of the slope and transfer the height horizontally on to the rest of the posts. After marking, cut the posts according to detail A on drawings No. 2 and No. 5. Note that if an alternative method is used, the dimensions of the beam at the joint must not be less than 10 cm.

After the main posts are cut into the right height the beams are placed on top of the posts and nailed with two 5" nails per post, one from each side of the beam.

Joining of the beam: It might be necessary if timber of the right lengths cannot be obtained or the crib is made up of several sections. The joint should be made as a half joint and placed over one of the main posts, detail B on drawing No. 2.

Erection of upper main posts: (Drawing No. 3 perspective view, No. 4 for cross sections and No. 5 for connection details). After the beams have been installed and secured, erection of the upper main posts can take place. This can be made easier if the posts are cut to the right lengths before erection.



Drawing No. 3. Erection of main frame off a 150 wide crib in 2 sections. Perspective view.

A: Mono-pitched roof meant for corrugated metal sheet roofing.
B: Couple-roof meant for thatched roofing.
All measures in cm.

Place the upper main posts on the beams in extension of the lower posts and secure with two 4" nails per post, one from each side, into the beam. Line the upper posts up in plumb and secure plumb with wall supporter and diagonals. To fasten the supporters use two 4" nails per post.

To further to secure the connection between the main posts and the beams, fix on both sides 10 gauge galvanized wire with 25 mm staples to the upper post across the beam to the lower post, see detail A on drawing No. 5.

Erection of rafters and purlins: (Drawing No. 3 perspective view, No. 4 for measurements and No. 5 for details). After erection and securing of the upper main posts nail the rafter to the top end of the main posts with two 5" nail per post, one from each side, and secure the rafters to the main posts, detail C on drawing No. 5, with 10 gauge galvanized wire fastened with 25 mm staples. Cut the purlins into the right length and nail them to the rafters with two 5" nails per rafter, one from each side. Stabilize the crib with one Ø 5 cm roof diagonal, per crib section, placed as shown on drawing No. 3, nailed to the rafters with two 4" nails per rafter.

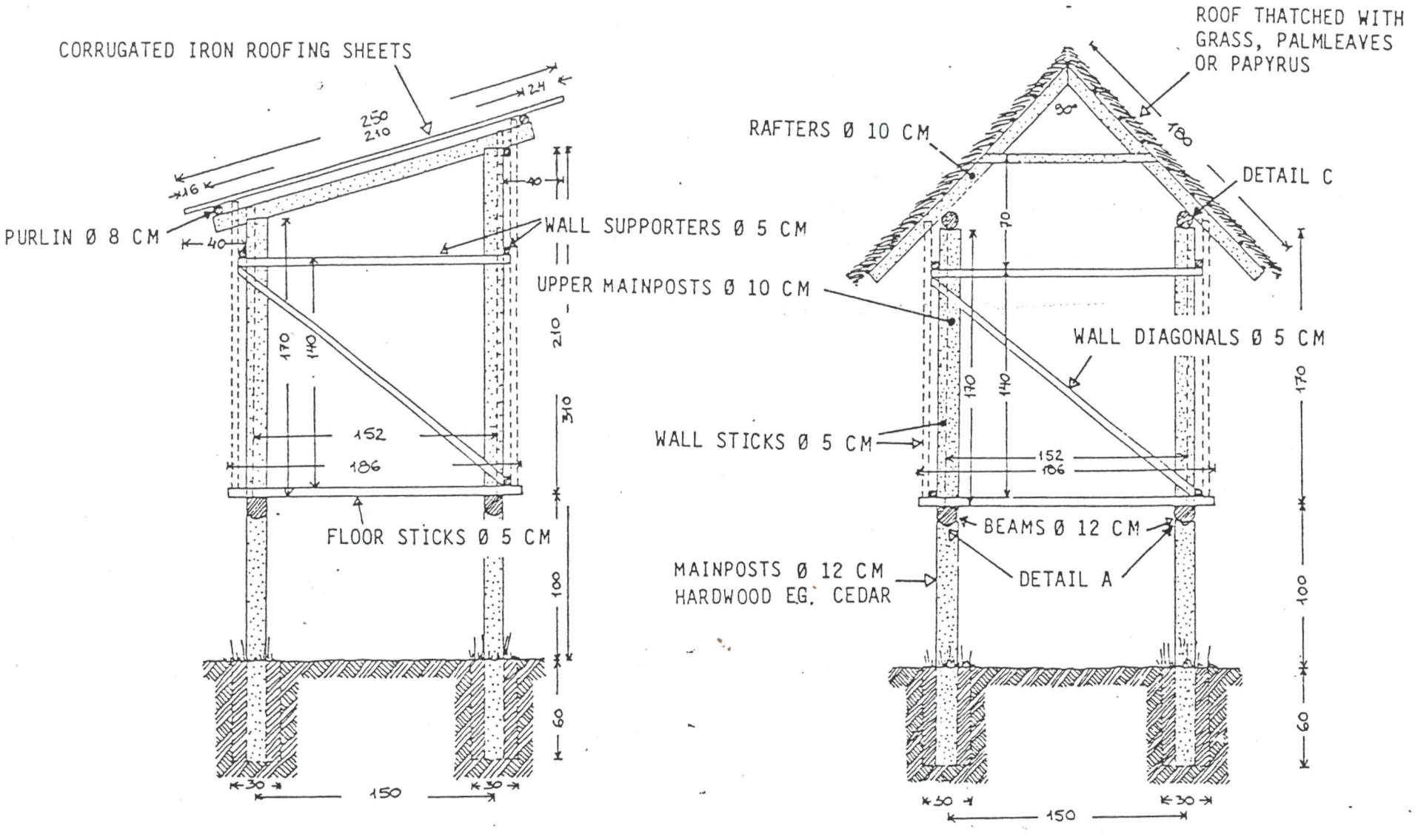
Installing the crib floor: (Drawing No. 6). Select the best sticks for the crib floor, diameter not less than 5 cm, and the sticks should be as straight and even as possible. Remove all the bark and cut the sticks into lengths. Place the first floor stick firmly up against the main post, same overhang on each side of the crib, and nail the stick to the beam with one 3" nail per stick. Place the next floor stick maximum 5 cm apart and parallel to the first stick. Note that if the spacing exceeds 5 cm, the maize cobs are likely to fall through the floor. These are continued up to the next main post, where the last floor stick is placed firmly up against the post. The second floor section is laid out in the same way as for the first section, and so on if there are more sections, i.e. in a longer crib.

Close the larger spacing between the floor sticks, developed at the middle main posts, with a floor stick resting on two supporters nailed on to the beams. Only applicable for cribs with two sections or more.

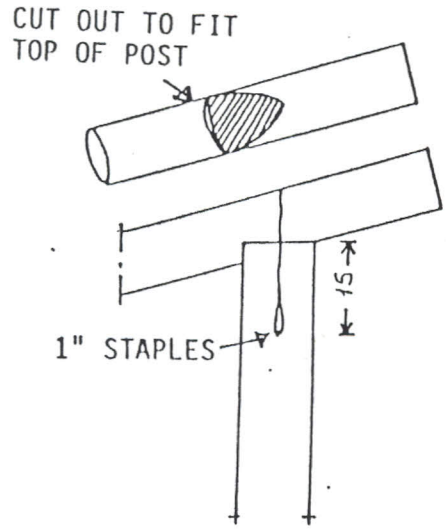
The walls

Installing the inner walls: (Drawing No. 6). The walls are built up as double walls, with one row of wall sticks on each side of the wall supporters, in order to prevent the rain from wetting the maize and to keep them from view.

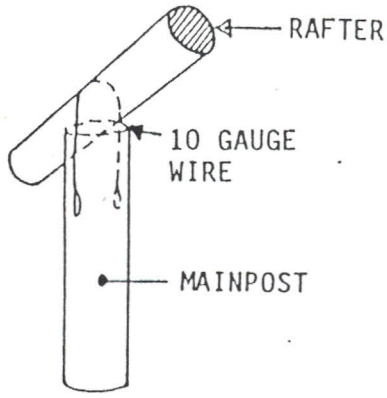
Place the inside wall sticks, at the facades, in the gap between the floor sticks so that they rest on the beams. It might be necessary to chop off the wall sticks to make them fit the gaps, and after checking the plumb and the spacing, nail the wall sticks to the wall supporters with one 3" nail per supporter.



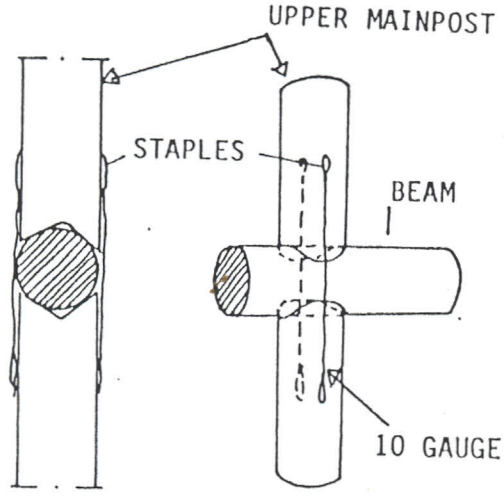
Drawing No. 4. Cross-section corresponding to drawing No. 3.
All measures in cm.

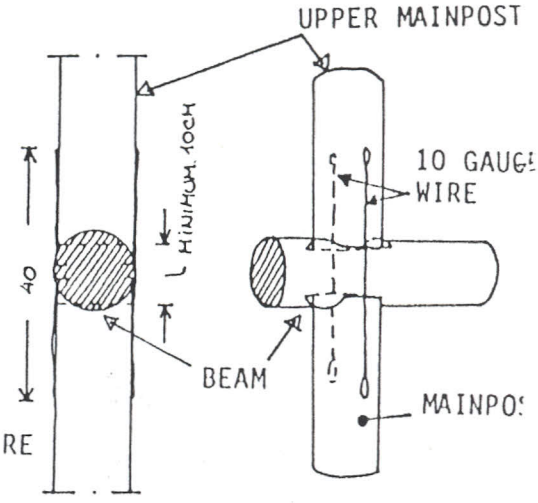


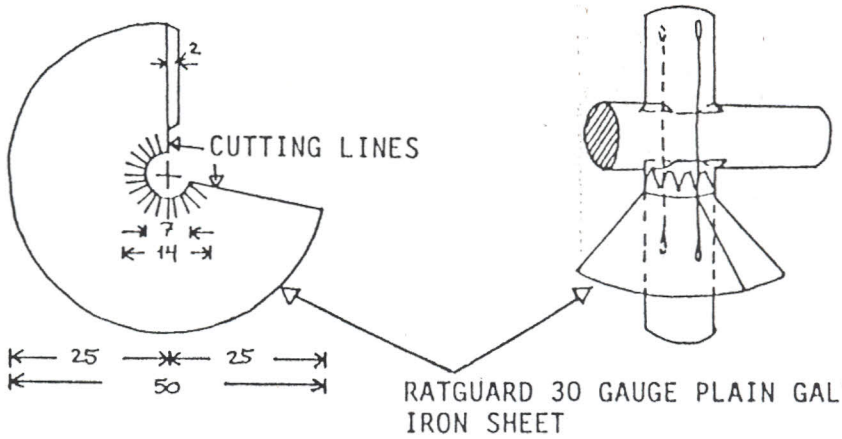
DETAIL A. CONNECTION BETWEEN BEAMS AND MAINPOSTS



ALTERNATIVE METHOD TO CONNECT THE BEAMS AND MAINPOSTS

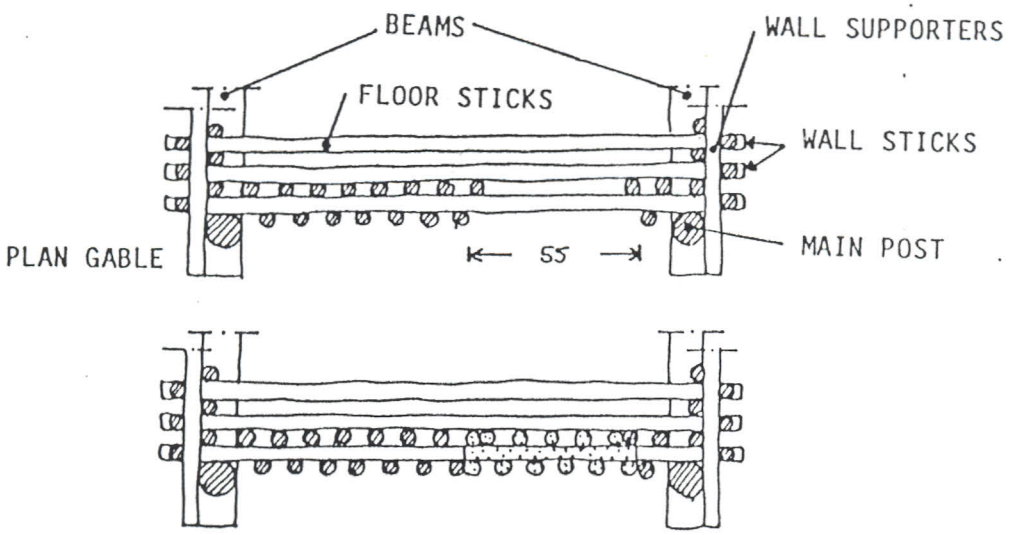




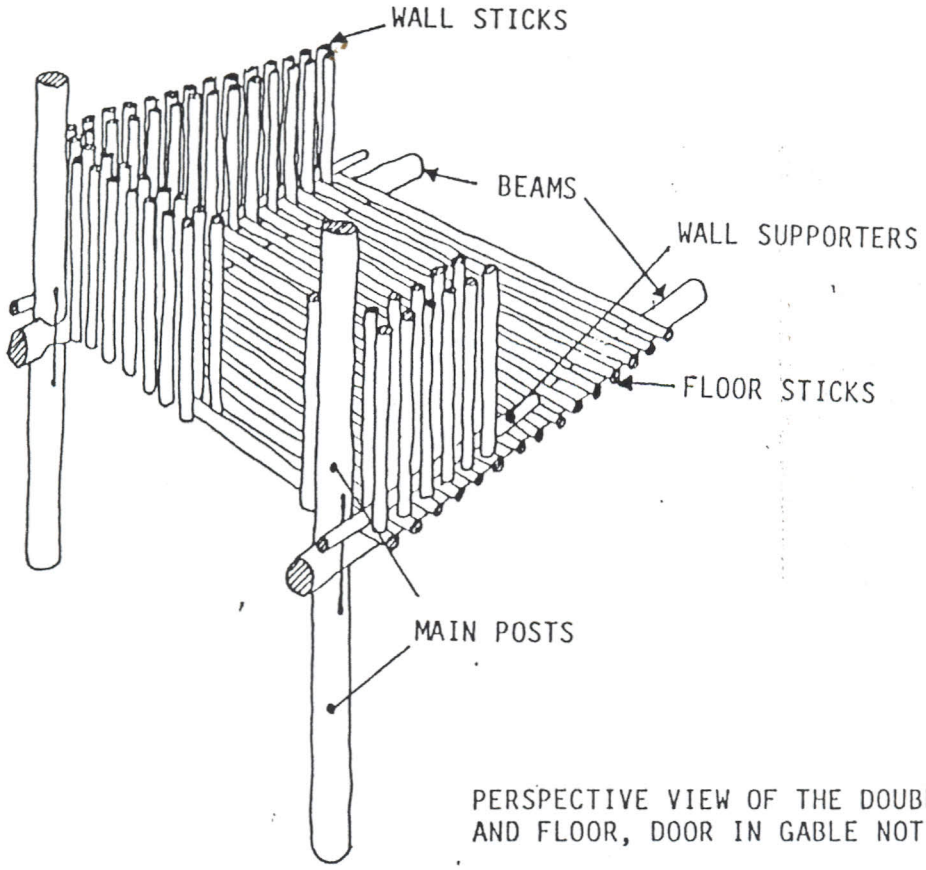


RATGUARD 30 GAUGE PLAIN GALVANIZED IRON SHEET

Drawing No. 5. Details A and C, connections between main posts - beams and rafters.
All measures in cm.



PLAN GABLE. DOOR IN CLOSED POSITION
SEE DRAWING NO. 7 FOR DOOR DETAILS



PERSPECTIVE VIEW OF THE DOUBLE WALL
AND FLOOR, DOOR IN GABLE NOT SHOWN

Drawing No. 6. Installing crib floor and double walls.

At the gables, place the wall sticks in the space between the first and second floor stick with a maximum spacing between the sticks, see drawing No. 6, and nail the sticks to the wall supporter with one 3" nail per supporter.

Installing the outer walls: (Drawing No. 6). Nail the outside wall sticks to the wall supporter with one 3" nail per supporter in such a way that the outer sticks cover the gaps between the inside wall sticks.

Wall openings: (Drawing No. 7). The crib is provided with two openings for loading and unloading, one in the gable, at floor level, for loading and removal of the maize, and one under the roof in the highest facade, for loading and for inspection of maize during drying.

The door: It is designed in such a way that in can stay closed without any locking device, and open as a top hinged door, or be removed completely. For security the door can be locked with a chain turned around the bottom doorledge and the wall supporter and locked with a padlock.

When constructing the door, the pattern of the sticks on the door has to be changed so that they fit into the gaps between the wall sticks. It might be necessary to adjust the dimension of the sticks on the door to make the door work satisfactorily, see drawing No. 7 for details.

The roof and the rat guards

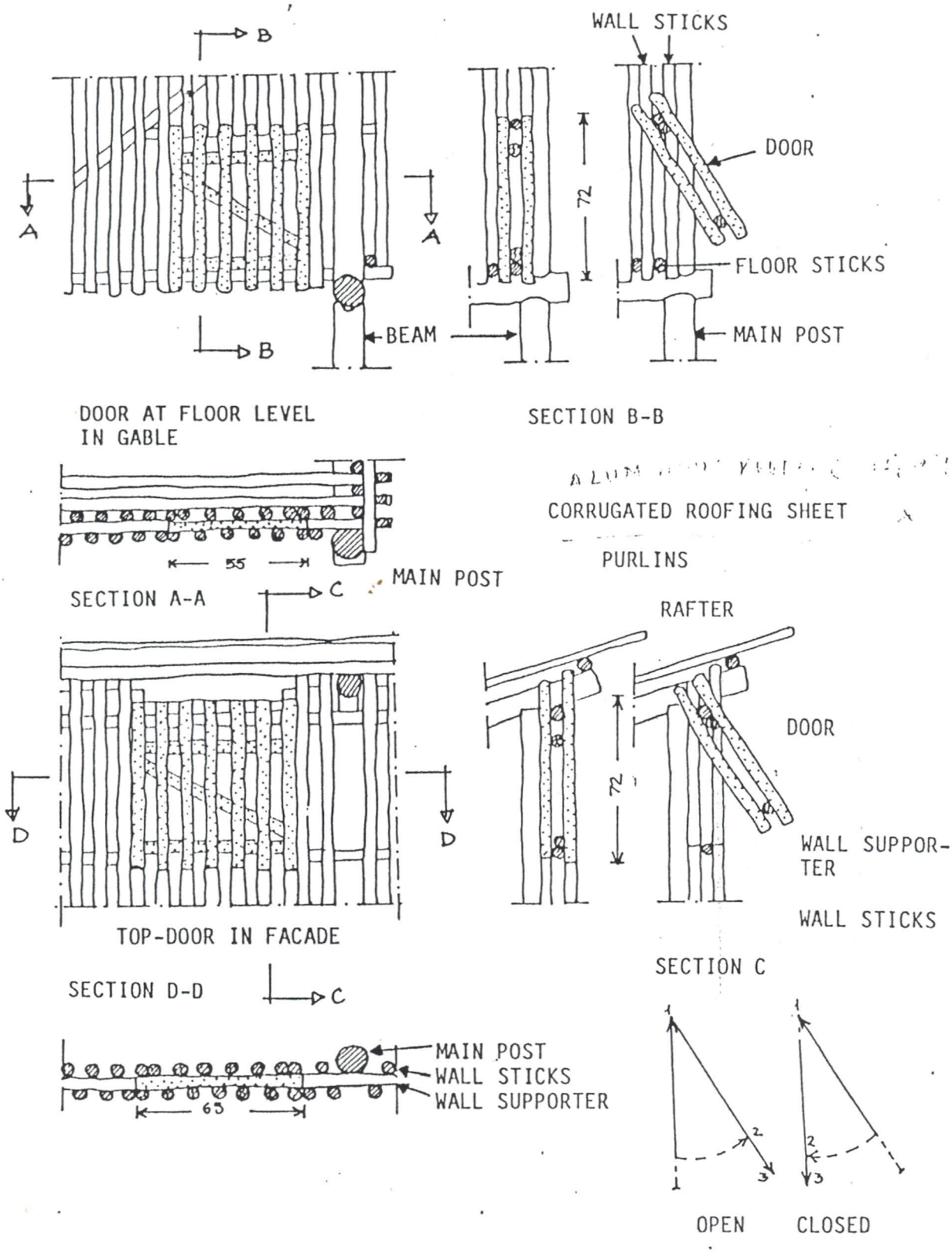
Roofing: (Drawing No. 8). The crib described is designed with a 15°, one-way sloping roof of 30 gauge galvanized corrugated iron sheets, laid with one corrugation side overlap and nailed to the purlins with six galvanized roofing nails per sheet.

As an alternative to the corrugated iron sheets, the crib can be covered with a thatched roof made of grass, papyrus or palm leaves (Makuti) but this requires the roof construction to be changed to a pitched roof. Drawings No. 9 and 10 show the same crib as described above fitted with a pitched roof.

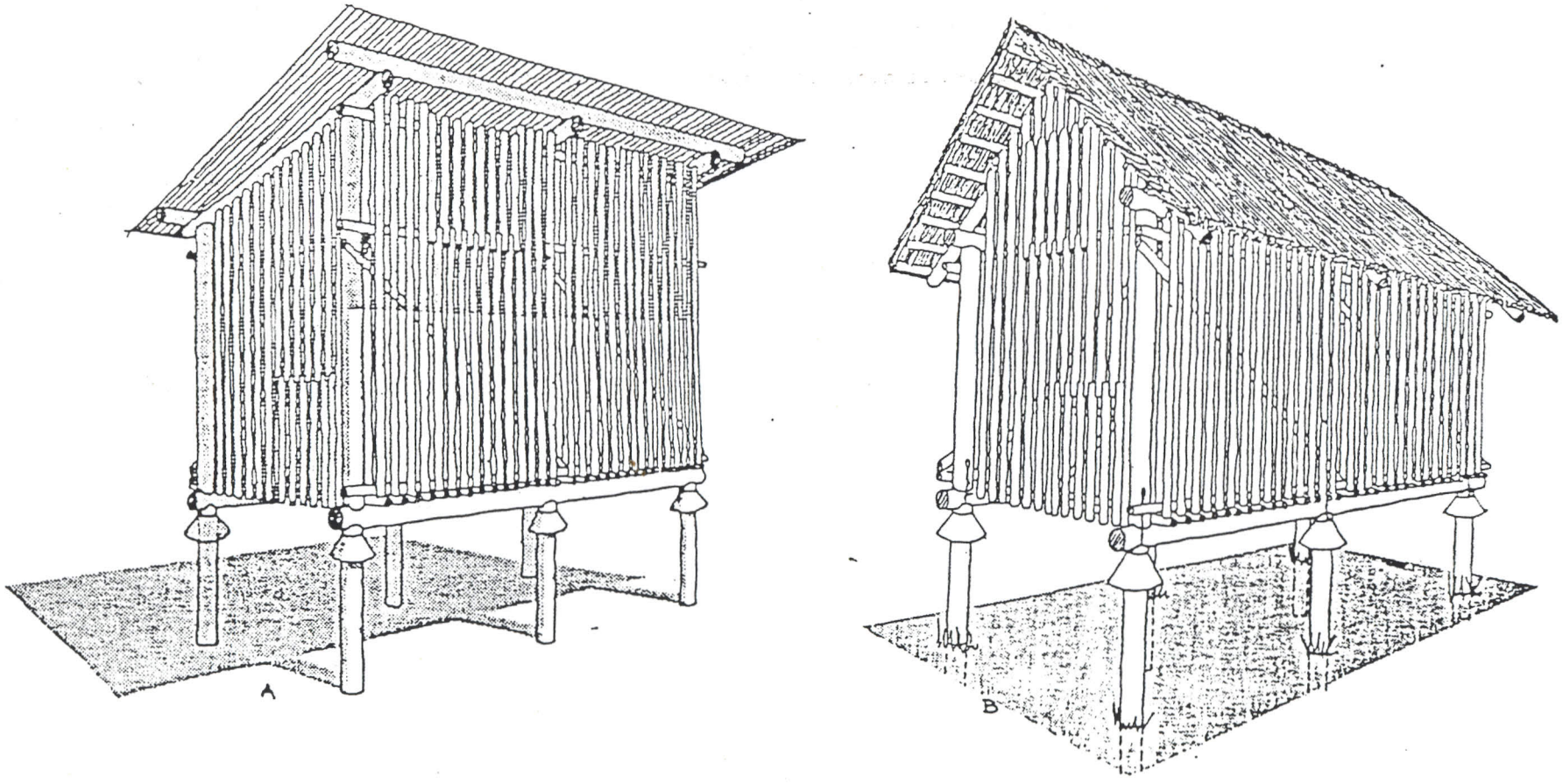
Rat guards: They should be fitted, as high as possible, on each leg of the crib to prevent rodents from entering the crib by climbing the main posts. Materials for the rat guards can origin from old oil tins or be made from 30 gauge plain galvanized iron sheets as shown on drawing No. 5.

Advantages and disadvantages

The crib described on the previous pages is created to satisfy the desires for a simple, appropriate structure making it possible to manage an early harvest of maize in the humid tropics.



Drawing No. 7. Installing doors in gable and facades.



Drawing No. 8. Completed structures. A: Mono-pitched roof structure

B: Pitched roof structure

The advantages of this crib as compared to the traditional crib structures are:

1. It is a strong durable structure having a lifetime of approximately 10 years.

2. It is rodent and bird proof.

3. The opening area of the walls is nearly the double of the void/solid ratio in the bulk maize.

4. The wall structure protects the maize from sun, driven rain and makes the stored produce non-visible to passing people.

5. It is easy to load and unload and it can be locked to protect against theft.

6. Locally available materials can be used for nearly 100% of the structure.

7. It can be utilized for both drying and storage of different products.

8. The maintenance is reduced to a minimum.

9. It creates a new standard for on-farm structures.

The disadvantages are few but might be of importance to some farmers:

1. The structure requires more capital investment than the traditional structures.

2. The construction requires more craftsmanship.

3. The 0.6 m crib does not utilize the timber very well.

9. ALTERNATIVE STRUCTURES

A "double-narrow crib" has been proposed, see drawing No. 9.

The structure seems very promising both in terms of better utilization of the timber and in terms of stability. It can in fact be placed on top of the ground on a very simple footing.

If the width of each of the two narrow cribs in the structure is restricted to 60-100 cm, it is very likely that the structure will perform very close to the rectangular 1.0 m wide singular crib.

Loading maize into these structures seems to be a little troublesome if there are more than two sections. It is, however a problem that might be solved during the testing period.

For dimensioning, strenght calculations and building technique, the figures, drawings and descriptions already given can easily be adjusted.

Multipurpose store

In areas where double cropping is practised or other crops like potatoes and beans are grown, the improved crib can be utilized more intensively by the introduction of small modifications.

The advantages of this are:

1. The storage costs per unit of weight are reduced.
2. The number of specific structures on the farm is reduced.

A two-section crib modified to store potatoes is shown in drawing No. 10. The inner walls and the floor are covered by mats.

The tray or playform

In an attempt to boost the drying rate it has been suggested to introduce the tray or platform either in the beginning of the drying process, 30-20% MC, or in the final stage, 18-13% MC, to achieve 13% MC before the shelling and storage. The drying rate is considerable as can be seen in Figure 4.6, and the utilization of the tray might cause the development of mixed drying -storage systems as lined out in Figure 11.1

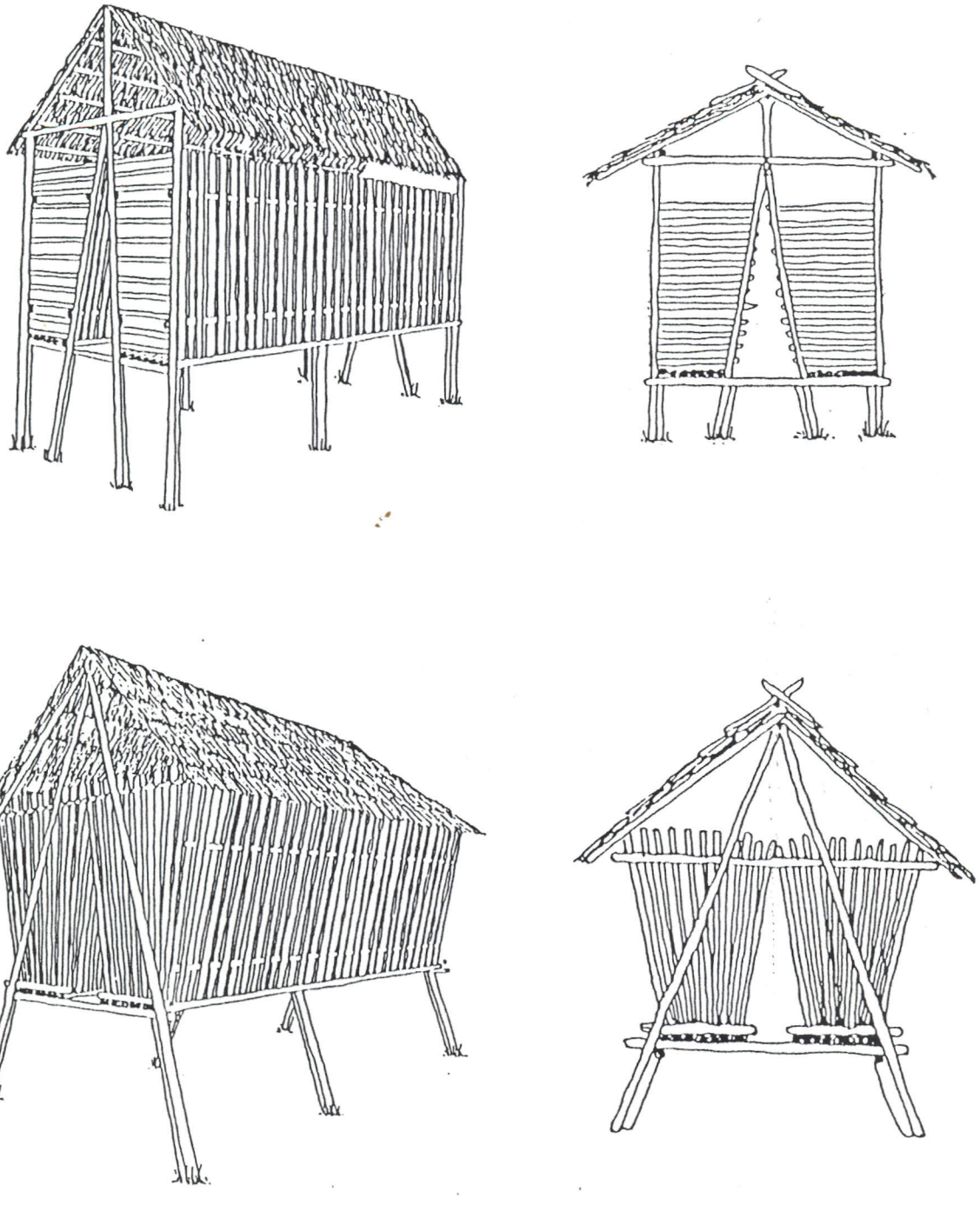
A simple drying platform is shown in drawing No. 11.

Alternative materials for crib structures

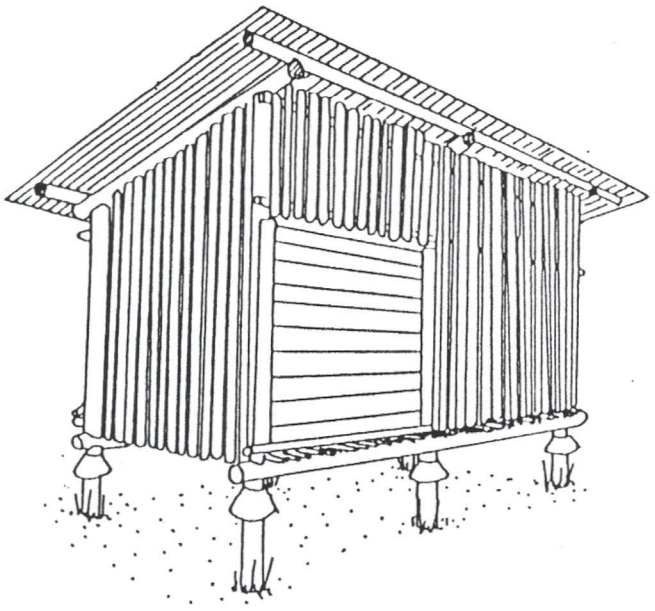
Cribs can be made of almost any available local building material: bush poles, bamboo or sawn timber. Where bamboo is available, it is the obvious material for the small farmer to use, since it is light to carry, very strong, easy to cut and available in long lengths. Un-

fortunately, it cannot be nailed and all structural members have to be tied together. In addition, it has a very short life and would have to be renewed every year.

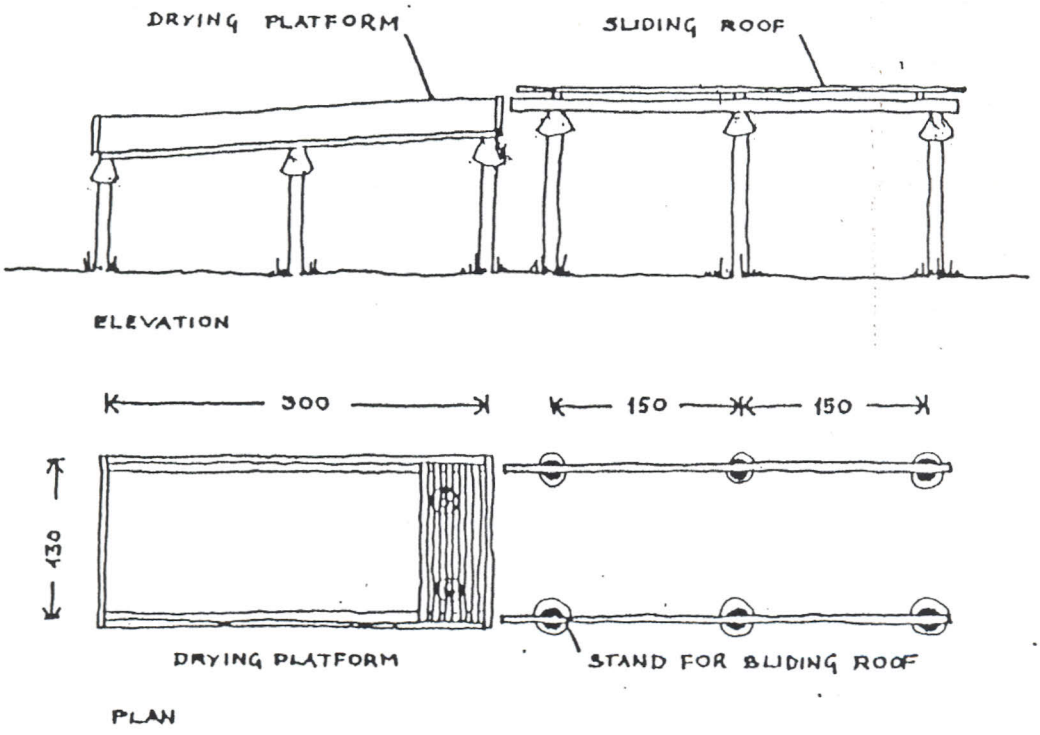
One example is shown in drawing No. 12.



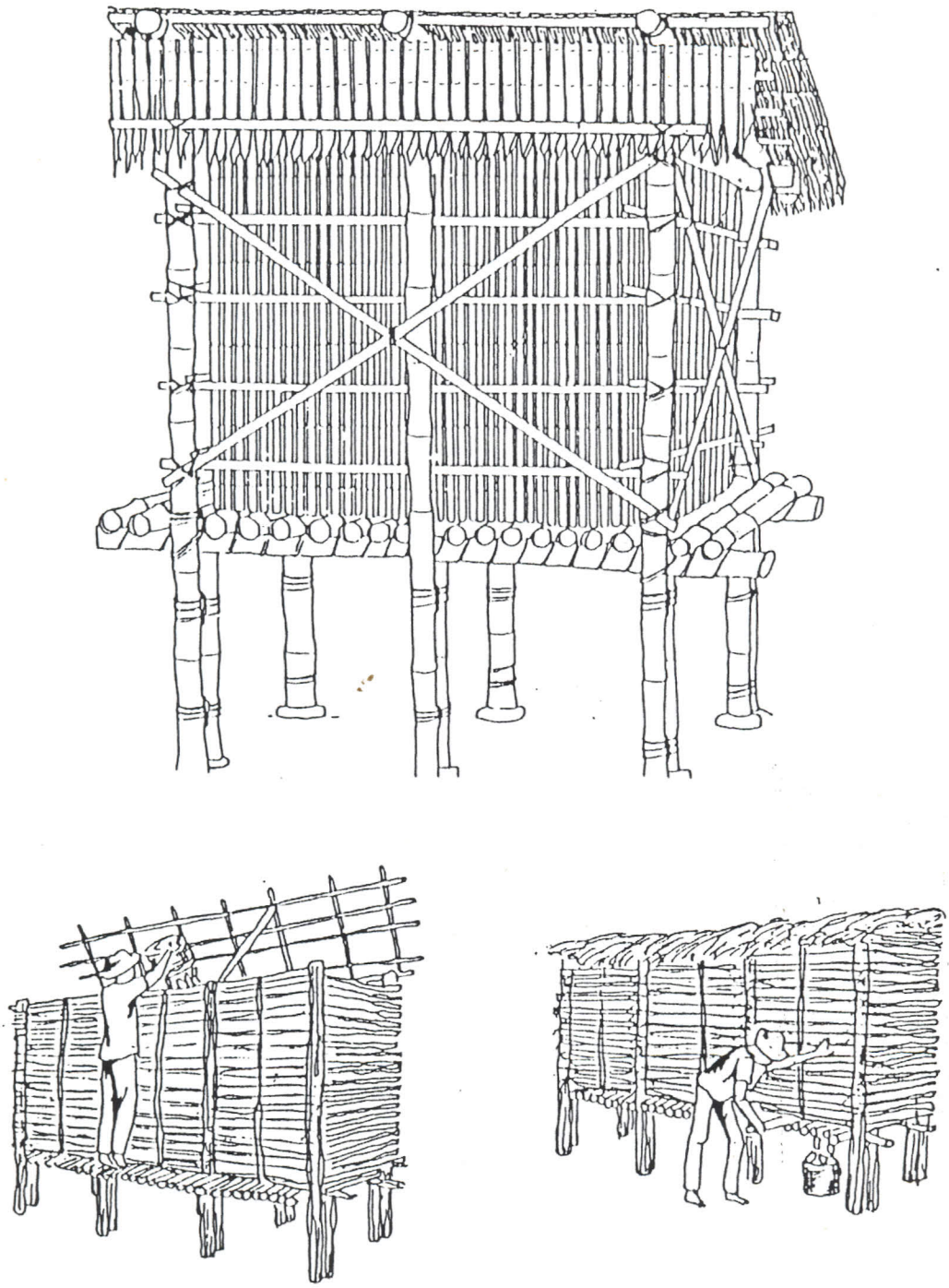
Drawing No. 9. "Double-narrow" crib.



Drawing No. 10. Crib modified for storage of potatoes.



Drawing No. 11. Drying platform with sliding roof.



Drawing No. 12. Crib built of bamboo.

*BUILDING AN IMPROVED DRYING AND STORAGE CRIB

Method 2

Tools and Materials

This is a guide. You can use what you have available. The frame is bamboo. If bamboo is not available in your area, or if the bamboo in your area is attacked by insect pests, use wood that is resistant to termites or any other pests. Lash it together the same way you would lash bamboo.

For the building frame (all bamboo or substitute):

(a) 3 vertical supports, 3 1/2m long, with V-notches and lashing slots in one end of each one

(b) 3 vertical supports, 3m long, with V-notches and lashing slots in one end of each one

(c) 2 horizontal roof supports, 2 1/2m long

(d) 2 horizontal platform (floor) supports, 2 1/2m long

(e) 6 vertical platform supports (with V-notches in one end of each), 1 1/2m long

(f) 6 notched horizontal width spacers, 70cm long

(g) 25 poles, 95cm long, for the platform surface

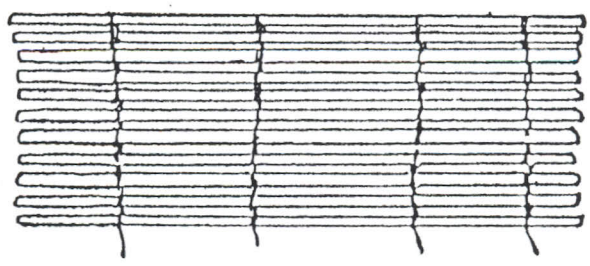
For the wall bracing and covering (raffia, small bamboo or other wood):

(h) 8 cross braces (optional if frame is very strong):
. 4 must be about 2 1/2m long
. 4 must be about 1,70m long

(i) 8 wall supports, 2 1/4m long

(j) 8 wall supports, 1m long

(k) raffia or other strong slats for the wall covering. Tie these together into a mat. The finished mat should be about 6m long and 1 1/2m high.



For the roof (all bamboo or substitute, except for purlins, and roof covering and loading cover):

(ℓ) 2 horizontal pieces, 3 1/4m long

(m) 3 cross pieces, 1m long

(n) 2 angle braces, 1m long

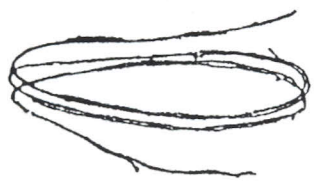
(o) 7 purlins, 3 1/4m long. Six of these will be lashed across the cross pieces to support the roof covering; one may be attached to the front loading cover.

(p) raffia mat or grass for thatch to cover the roof, and also for the front loading cover. You will need a horizontal piece at least 2 1/4m long to weave the loading cover material onto -- it need not be bamboo or of a large diameter.

For rat guards (See page 92).

For the lashing material:

(q) You will need plenty of rattan, rope or tie vine for lashing all the wood pieces together.



1. Select a site.

   . Find a good site for your storage crib. Keep the crib away from the fields. This stops insects from flying to the drying grain from the fields.

2. Prepare your materials.

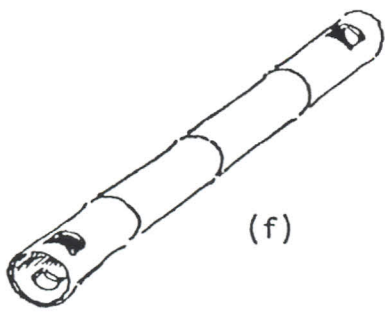
   . Collect all the materials you will need.

   . Make V-shaped notches in one end of each of the three 3 1/2m vertical supports (a), and cut some grooves on each side just beneath the notches to provide a hold for the lashing there. Do the same on one end of each of the three 3m vertical supports (b).

(a) & (b)

- Make V-shaped notches in one end of each of the six 1 1/2m vertical support posts (e).

(e)



(f)

- Make holes all the way through each end of all six 70cm horizontal spacers (f).

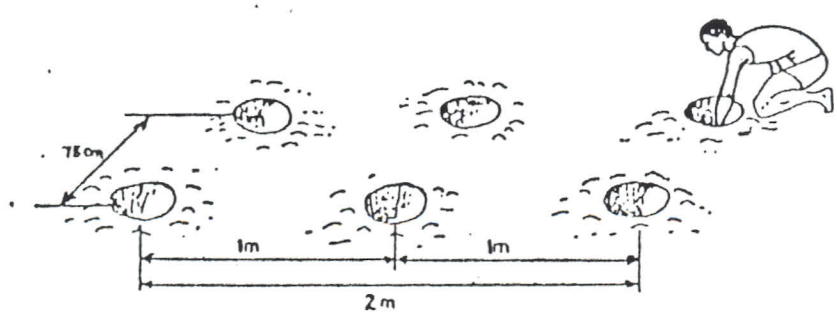
- Organize all the pieces, or mark them with the appropriate letters, so you can find them quickly during construction.

3. Make holes in the ground for the legs.

- Mark spots for holes for the vertical supports (legs)(a) and (b) on the ground. Make a mark for the first hole; measure 1m and make another mark. Measure 1m from that mark in the same direction and make a third mark. You should now have 3 marks in a straight line. Each mark will be the center of a hole.

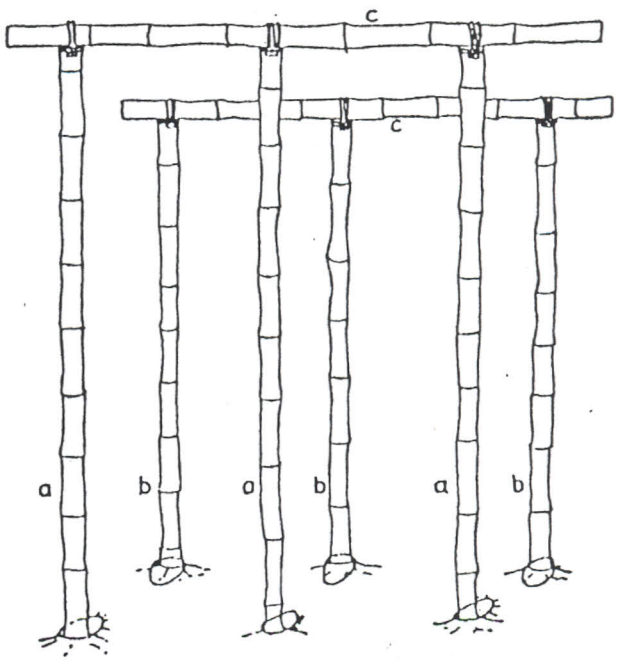
- Make three more marks, each 1m apart, in a line parallel to the first line and 75cm away. Each of the three new marks should be directly opposite one of the first marks and 75cm away.

- Dig six holes, each centered on one of the marks. Make the holes 50cm deep and wide enough so that <u>two</u> vertical supports will fit down into each one.



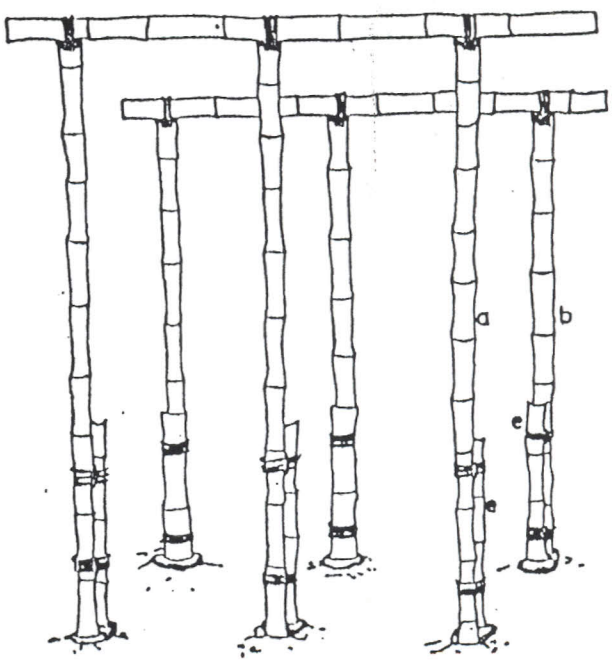
4. Erect the vertical supports.

- Lay the three 3 1/2m vertical supports (a) on the ground 1m apart, with their ends lined up. Lash one of the 2 1/2m horizontal roof supports (c) to the notched ends.
- Lay the three 3m vertical supports (b) on the ground in the same way and lash the other horizontal roof support (c) to the notched ends.
- Place the two assemblies into the holes.



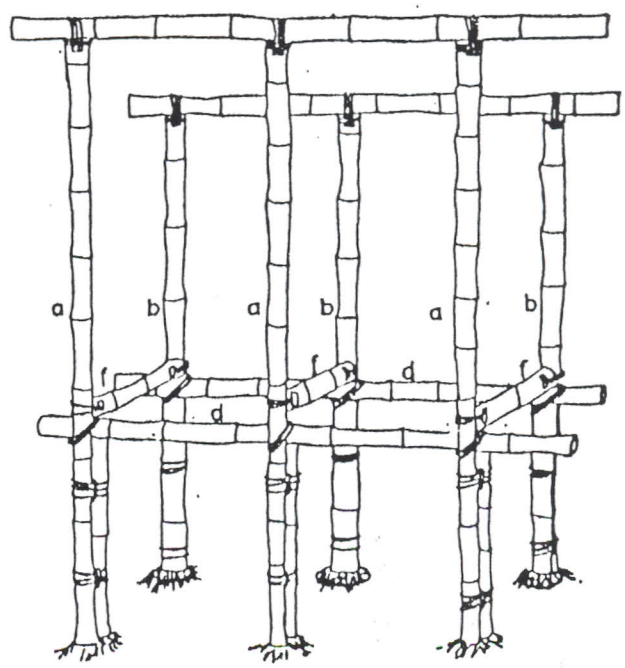
5. Erect the vertical platform supports.

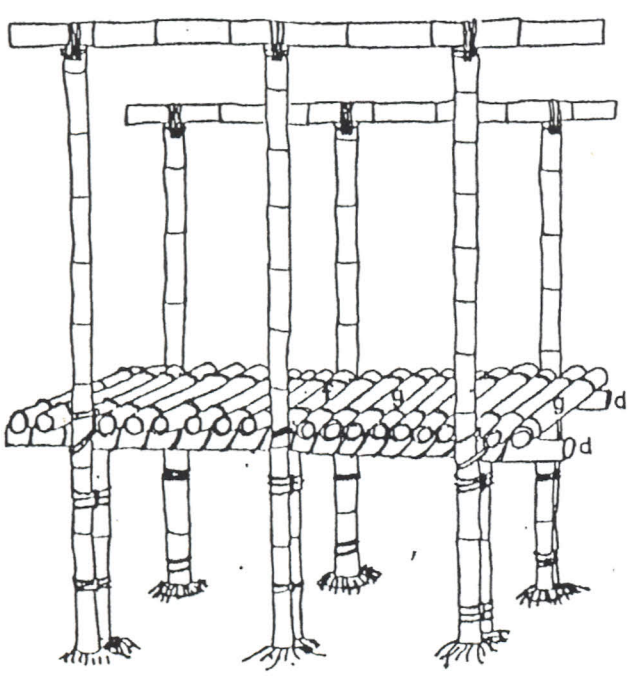
- Place the vertical platform supports (e) into the holes on the insides of the vertical supports you have placed in the holes. Make sure the V-notches are facing upwards.
- Tie the platform supports to the longer supports temporarily until the next step is completed.



6. Install the platform support framework and make the structure rigid.

- Place the two horizontal platform supports (d) in the V-notches of the platform supports.
- Lash three of the notched horizontal spacers (f) to the vertical supports (a) and (b), across the width of the crib.
- Level and square the framework.
- Fill the holes around the vertical supports with small stones and soil. Tamp down firmly.
- Lash all joints tightly.

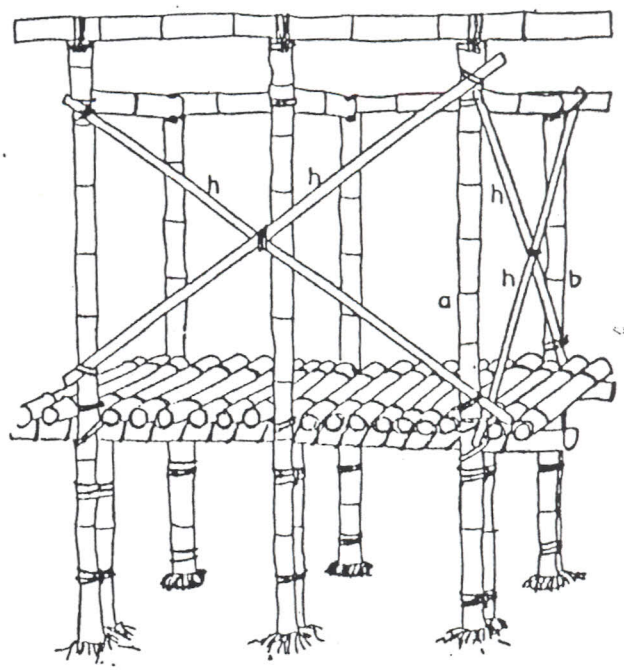




7. Finish the platform.

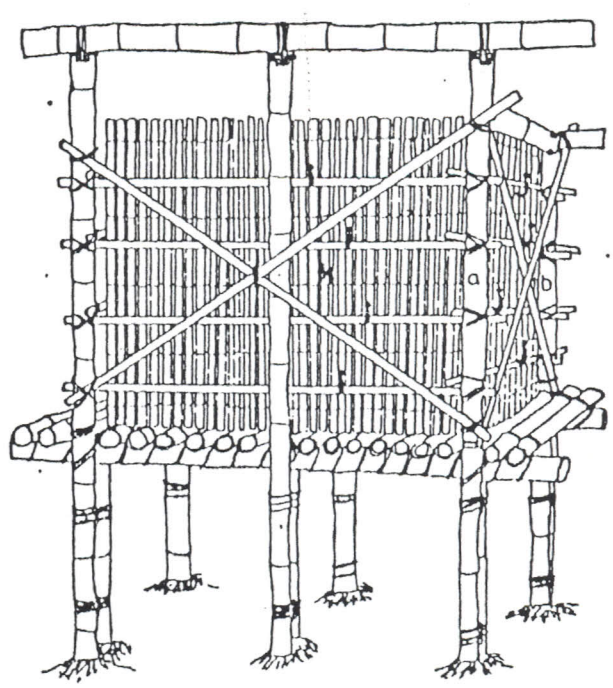
- Lash the twenty-five 95cm poles (g) next to each other on the horizontal platform supports.. This forms the platform.

8. Install the cross braces.



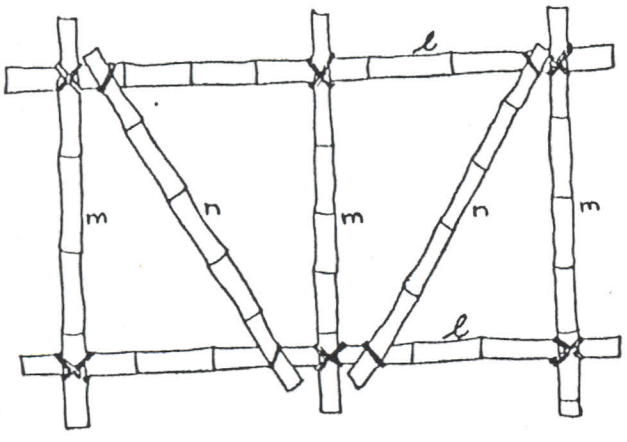
- If you think the frame is not sturdy enough by itself, lash the cross braces (h) loosely to the vertical supports on the outside of the crib.
- The 2 1/2m cross braces are paired on the long sides of the crib, and the 1,70m cross braces are paired on the ends of the crib.
- Each brace should extend from somewhere near a top corner to somewhere near the opposite bottom corner. Leave room for a loading cover on the higher side of the crib.
- Make sure the frame is straight and even. Lash the braces securely.

9. Install the wall supports and wall covering.



- Lash four of the 2 1/4m wall supports (i) to the vertical supports along the inside of one of the long sides of the crib. Lash the remaining four supports to the inside of the other long side of the crib.
- Lash four of the 1m wall supports (j) to the vertical supports along the inside of one end of the crib, and four of them along the inside of the other end.
- Lash the already-prepared wall covering, 6m x 1 1/2m (k), to all the wall supports on the inside of the frame.

10. Build the roof.

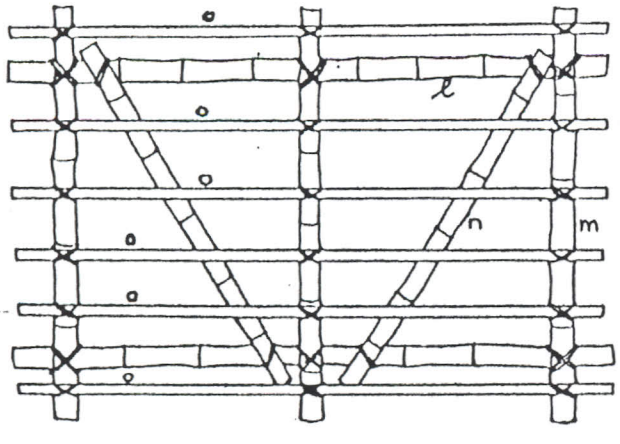


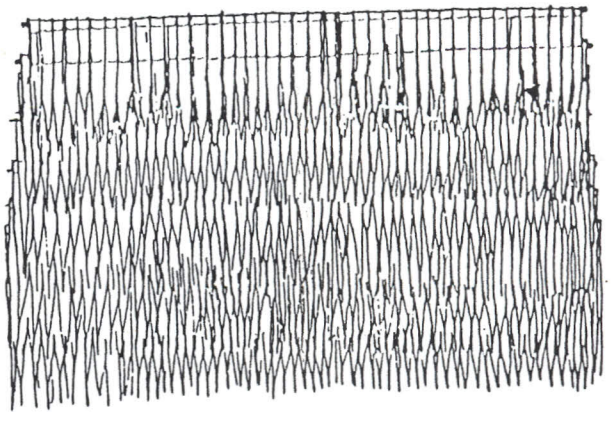
. Call the high side of the crib the front and the lower side the back.

. Measure the distance between the centerlines of the front and the back horizontal roof supports (c) which are lashed to the tops of the vertical supports (a) and (b).

. Lay out the two 3 1/4m horizontal roof pieces (ℓ) on the ground so their centerlines are the same distance apart as the measurement you have just made.

. Lash the three 1m cross pieces (m) on top of the horizontal roof pieces, 1m apart. When the roof is placed on top of the frame, the cross pieces should cross over the ends of the vertical supports of the frame.



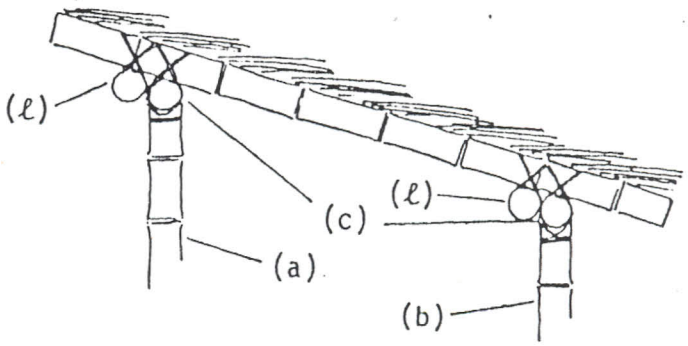


. Lash the two 1m angle braces (n) to the horizontal roof members so that they extend diagonally across the two spaces in the roof frame.

. Lash six 3 1/4m purlins (o) on top of the three cross braces so that they extend longways along the roof frame. Lash the first and last purlins near the ends of the roof cross braces.

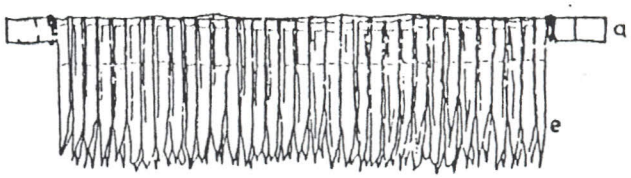
. Lash raffia mat in overlapping layers to the roof frame.

11. Install the roof.



- Place the roof on top of the frame as shown (looking at the end).
- Lash the roof in place.

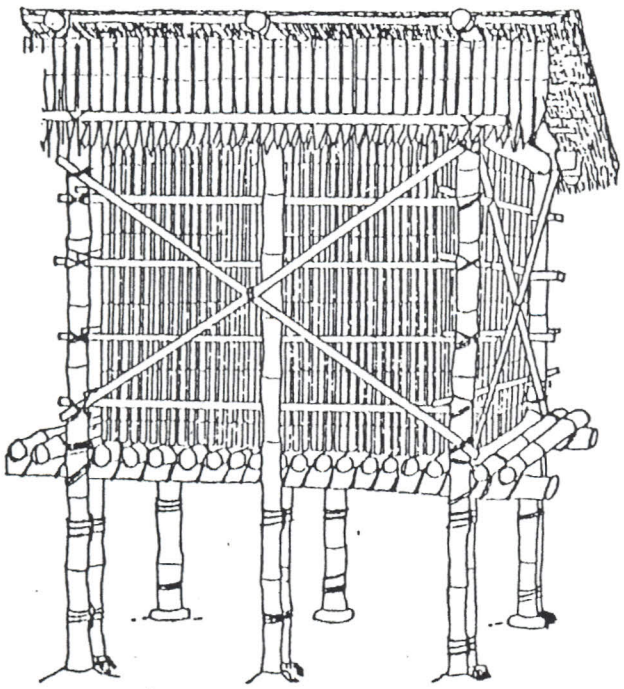
12. Make and install a front loading cover.



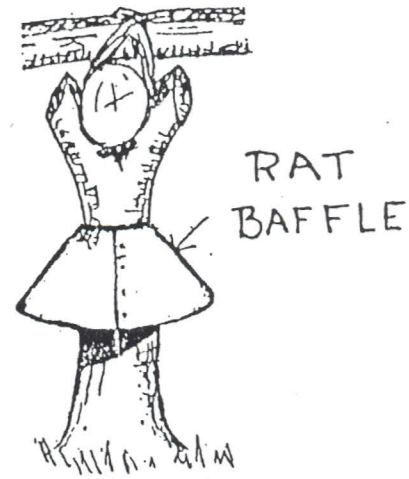
- Lash raffia mat to a 2 1/4m long bar to form the front loading cover. The mat should be made large enough to hang down beyond the top edge of the wall covering when the bar is lashed in place up under the front edge of the roof.
- Lash the bar holding the raffia mat up under the front horizontal roof piece.

13. The crib is ready for use.

- Load the crib. Lash down the bottom corners of the loading cover to the frame during drying and storage.



Rat baffle or guard



Materials and Equipment

* 1 flat tin sheet (30 gauge, 0.9 x 2m)

1 pair tin shears or sharp chisel

1 hammer

Chalk, charcoal, or large nail for drawing baffles on tin sheet.

25, 4-6cm nails (You will need 5 nails for each baffle)

Baffles should be about 50cm in diameter at the narrow end. The size will vary with the size of the leg which the baffle must fit.

. Mark out baffles on tin sheet with chalk or charcoal before cutting them out.

. Cut out along the outside edges. Do not cut the middle yet.

. Start with the thinnest leg first. Cut out the hole in the middle of the baffle little by little. The baffle must fit tightly to keep even the smallest rodent from climbing between the baffle and the leg. If the hole in the baffle gets too big for this leg, use it on a fatter leg.

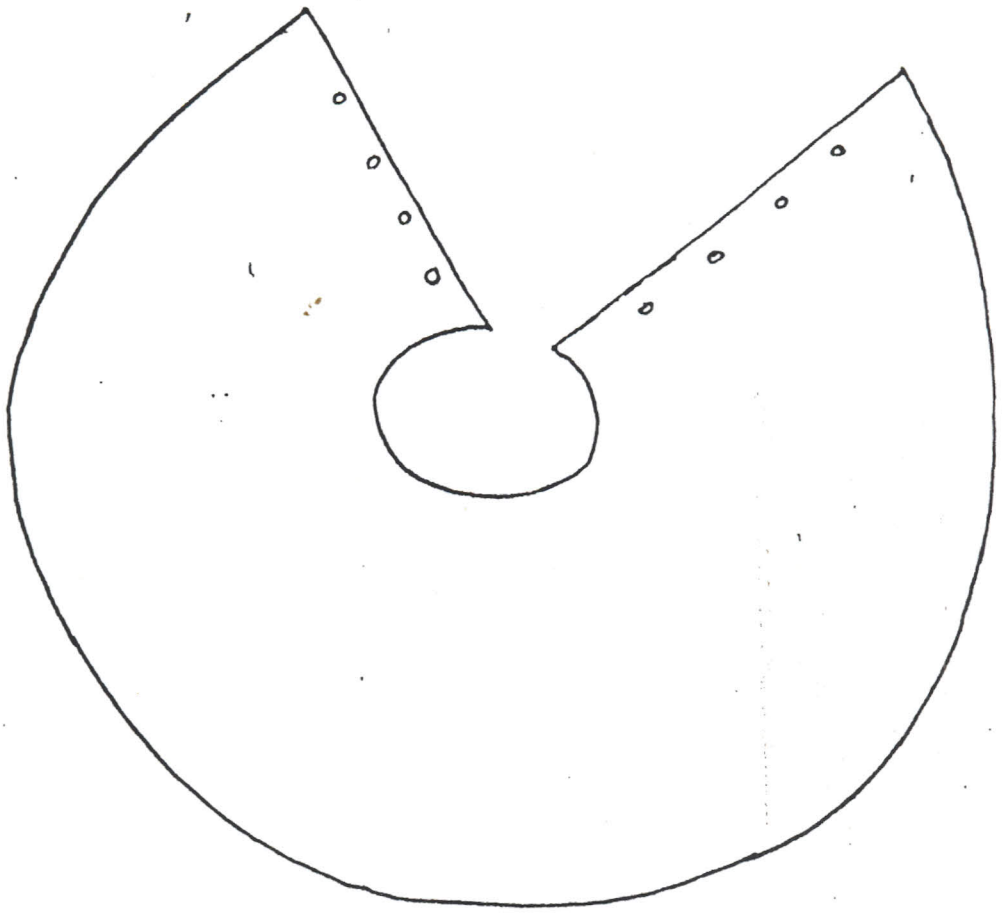
. Nail the baffle tightly to a wooden leg. Use cement mortar to fasten the baffle to a concrete leg.

. Cut out and fit all the baffles in the same way.

. Make wooden legs round, if they are not round already. Cut the middle hole of the baffle to fit a concrete leg which is not round.

NOTE: You can use whatever thin metal is available. Old tin cans can be cut and flattened.

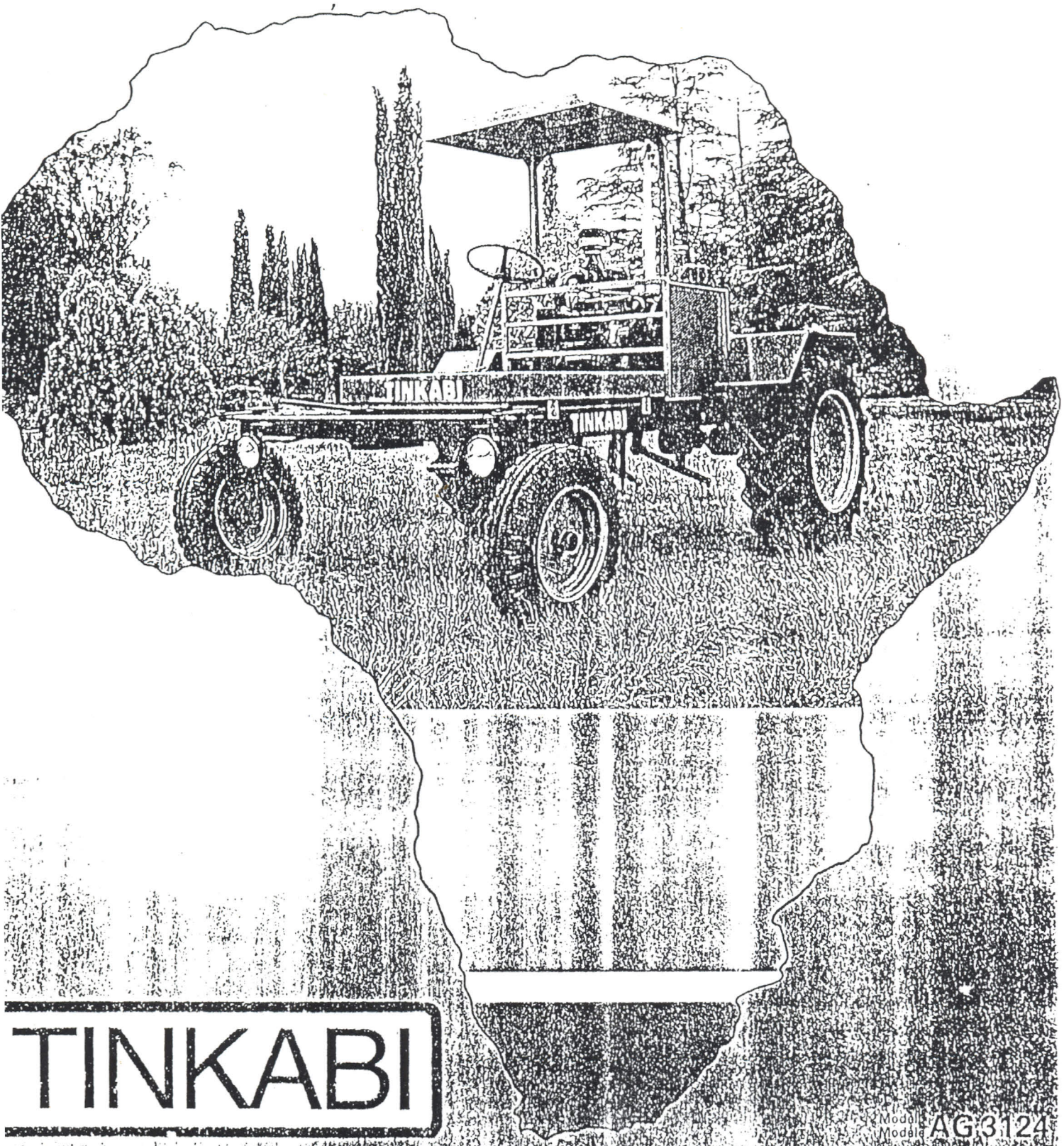
Below is a pattern for a rat guard to be cut from a piece of tin or a flattened tin can. This piece is cut out and bent to form a cone with a hole in the center. It is fastened around the leg of the crib or storage building and attached to the leg with nails or wire.



Annex 10

PORTE OUTIL RURAL TINKABI

TINKABI POWER SYSTEMS



TINKABI

Model
Modèle AG 3124

PORTE OUTIL RURAL TINKABI
TINKABI POWER SYSTEMS

- Construction simple, robuste et de bon fonctionement garanti, spécialement conçu pour faire face aux conditions ardu du continent africain.
- Étant une automotrice de fonctionnement universel et porte outils convenant à un grand nombre d'usages tant ruraux qu'industriels
- Pourvue d'un levier unique pour marche avant ou arrière et pour le changement de vitesse, la machine ne requiert qu'un minimum d'entretien d'ailleurs très simple. Elle peut donc être utilisée avec un maximum d'efficacité et en toutes circonstances.

Avantages spécifiques

- Moteur diesel efficace, de rendement éprouvé, renommé pour sa basse consommation en carburant.
- Conduite aisée due au système de propulsion hydrostatique étanche, varié à l'infini.
- Pneus et roues agrotraction spécialement conçus pour le labourage.
- Une benne large idéalement posée pour le transport de personnel, de machinerie, de produits et de matériaux de toute sorte, etc.
- Attelage à trois points (Categorie I) pour rélevage hydraulique à l'action rapide, pour machines agricoles montées.
- Equipment électrique complet, installé, avec lumières.
- Parasol de protection.
- Courroies auxiliares pour faire entrainèe diverses pièces d'équipement supplémentaires telles que: marteau-broyeur, pompe de l'eau, scie circulaire.
- Hauteur de passage sous pent élevé combiné avec large empattement idéal pour culture interlinéaire.
- Le large empattement renforce la stabilité de la machine en bordure de dénivellations.

Caractéristiques

Moteur: Diesel 3 cylindres à injection directe, refroidessement à l'eau développant 31 kW à 2000 t/mn pourvu d'un alternateur et d'un démarreur – filtre à aire à deux éléments de grande capacité et prefiltre centrifuge. Radiateur tropical avec ventilateur en poussé.

Transmission: Hydrostatique, roues motrices individuelles.

Pompe: À piston axial avant-arrière, bi-directionnelle a débit variable. Levier de contrôle manuel – débit: 72 litres par minute à 2000 t/mn. Pression maxi-

- Simple, rugged, reliable power unit specially developed for the arduous African conditions.
- Universal prime mover and tool carrier ideal for wide variety of rural and industrial applications.
- One lever operation forward, reverse and speed change together with low and simple maintenance ensuring best utilisation in all conditions.

Benefits and features

- Reliable, efficient proven diesel engine renowned for fuel economy.
- Infinitely variable sealed hydrostatic drive ensures ease of operation.
- Agricultural traction tyres and wheels for tillage applications.
- Large transport platform ideally suited to carry people, implements, produce, materials, etc.
- Fast operated three point hydraulic lift linkages (Category I) suitable for standard agricultural implements.
- Full electrical system with lights.
- Sun canopy for protection.
- Auxiliary belt drives to power various ancillary equipment such as hammermill, water pump, circular saw and spraying equipment.
- High clearance wide wheel based unit ideal for inter-row cultivations.
- Wide wheelbase ensures side hill stability.

Specifications

Engine: 3 Cylinder direct injection water cooled diesel engine developing 31 kW at 2000 e.r.p.m. Equipped with alternator and starter motor. Large capacity dual element, dry air cleaner with centrifugal pre-cleaner. Tropical radiator with pusher fan.

Transmission: Hydrostatic, with drive motor on each wheel.

Pump: Bi-direction axial piston variable displacement. Hand control lever. Displacement at 2000 r.p.m., 72 litres per minute. Maximum pressure 240 bars. Integral drive from engine. Pump maximum speed 3900 r.p.m.

Motors: SL 150 radial five piston with 4 : 1 epicyclic reduction gearbox for direct wheel mounting. Maximum torque output 219 kgf/m at 300 bars. Horse power output per motor at 219 kgf/m 14,8. Motor gearbox capacity 0.25 litre SAE 90 EP gear oil.

Filter: 10 Micron cartridge type.

Steering: Recirculating ball type, 17 : 1. All joints

mum: 240 bars. Force motrice fournie intégralement par le moteur. Vitesse maximum de la pompe: 3900 t/mn.

Moteurs: Tipe SL 150 radial, cinq pistons, boite de vitesse à réduction épicyclique 4 : 1 montée directement sur la roue. Débit maximum du couple: 219 kgf/m à 300 bars. Debit CV par moteur à 219kgf/m: 14,8. Capacité de la boite de vitesse du moteur: 0,25 litre d'huile de boîtier tipe SAE 90 EP.

Filtre: Tipe à cartouche, de 10 microns.

Direction: Tipe à bille recirculée, de proportion 17 : 1 roulements en rosace avec tous joints lubrifiés, et bagues de nylon auto-lubrifiées pour chevilles goupille et le pivot axial.

Rélevage hydraulique:

Effort de levage:	sans lest	860 kg
	roues avant lestées maximum	1300 kg
Roues et pneus:	Avant	600 x 16 6 plis
	Arrière	12,4/10 x 24 6 plis
	Pneus traction	
Dimensions:	Larguer hors-tout	2,10 m
	Longueur hors-tout	2,50 m
	Hauteur hors-tout	2,50 m
	Hauteur de passage sous chassis	0,60 m
Voie:	Avant	1,83 m
	Arrière	1,89 m
	Rayon de braquage	11,60 m
Masse:		1700 kg
Vitesse:		0–20 km/h
Capacites:	Réservoir carburant	25 litres
	Réservoir hydraulique	60 litres
	Refroidisseur	10,2 litres
	Carter (du moteur)	6,8 litres

Vélocite d'entrainement auxiliaire: 2000 t/m

Capacite de chargement: 1000 kgs

lubricated rose bearings and nylon self lubricating bushes for king pins and axle pivot.

Hydraulic lift: Lift capacity unballasted: 860 kg

Ballasted on front wheels up to: 1300 kg

Wheels and tyres:	Front:	600 x 16 6 ply
	Rear:	12,4/10 x 24 6 ply
	Traction tyres	
Dimensions:	Overall width	2,10 m
	Overall length	2,50 m
	Overall height	2,50 m
	Ground clearance	0,60 m
Wheel track:	Front:	1,83 m
	Rear:	1,89 m
	Turning circle:	11,6 m
Mass:		1700 kg
Speed:		0-20 km/h
Capacities:	Fuel tank:	25 litre
	Hydraulic tank:	60 litre
	Cooling system:	10,2 litre
	Oil sump (engine):	6,8 litre

Auxiliary drive speed: 2000 r.p.m.

Carrying capacity: 1000 kg

TINKABI

marque/by

ISICO

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Annex 11

CASSAVA STARCH

There is no industry for manufacturing cassava starch in Ghana. Ghana imports nearly 1500 tons of starch a year.
Starch is used for manufacture of glucose and dextrose. Cassava starch is more popular than maize or potato starches owing to very low protein content in the cassava.
Dextrose is used in the fruit canning industry, confectionery, bakery industry and ice cream factories. It is also used in the food industries as custard, thickener in soup, baby food, sauces and gravies; in the textile industries for wasping thread on looms; in the printing industry to improve stiffness, and in the laundry industry. Starch is used to improve, the strength of paper and for paper board boxes.

A starch industry was established near the Volta River bridge in Akuse but due to Kpong/Akuse Hydro project, it was moved away and never started again.

In order that cassava starch is accepted by the industry the following quality standards need to be achieved.
Appearance: Colour and specks shall be uniform white and free from pigment. A trace of yellow colour would be accepted for average requirements.

Mesh - 99% starch to pass throsugh 100 mesh screen
Pulp - 0.8% maximum
Odour - Should be clean and fresh
Protein - 0.4% maximum
Moisture - the moisture content between 10÷13.5%
Ash - 0.35% maximum
Acidity - Ph value shall be 4.5 - 5.5
Sulphur dioxide - less than 45ppm

The technology is simple, the machines can be obtained in Ghana.

- Washing of tuber
- Tubers are peeled with cassava peeler
- Peeled tubers are washed again
- Washed peeled tubers are grated with cassava grater
- Grated cassava is transferred to bleaching tank; SO_2 solution 0.2% is added if necessary
- Pumped to shaking, washing and refining screen
- Washing screen is lined with 80 mesh bronze
- Pomace shaken out from this sieve is given second washing in second shaker lined with 120 mesh nylon cloth
- milk goes into slurry bin
- Pulp goes to pulp bin
- 20 misuse absence of discolouring stainless steel, aluminium or bronze material to be used
- Centrifugal fillers are best adapted for devalescing the pulp
- Milk coming from the bin is sent directly to centrifuge
- The escaped starch and fruit waters are pumped to a settling tank, after giving 4-6 hours for starch to settle, water is gradually let out. Fresh water is introduced, agitator is put to work. As the starch attains density of 20°C, Baume, slurry pump is switched to transfer the milk to the centrifuges. Water is finally taken out leaving a moisture content of 35 to 40 percent on the starch. In case of pulp, centrifuge separates the water or dehydrated by bydraulic press. Starch coming from press or centrifuge is broken, sieved and dried into tunnel dryer or endless belt steam drier. Pulverising starch coming from the drier into small lumps which is ground, pulverised by a pulverizer or stone mill. Starch powder is graded, bagged and despatched.

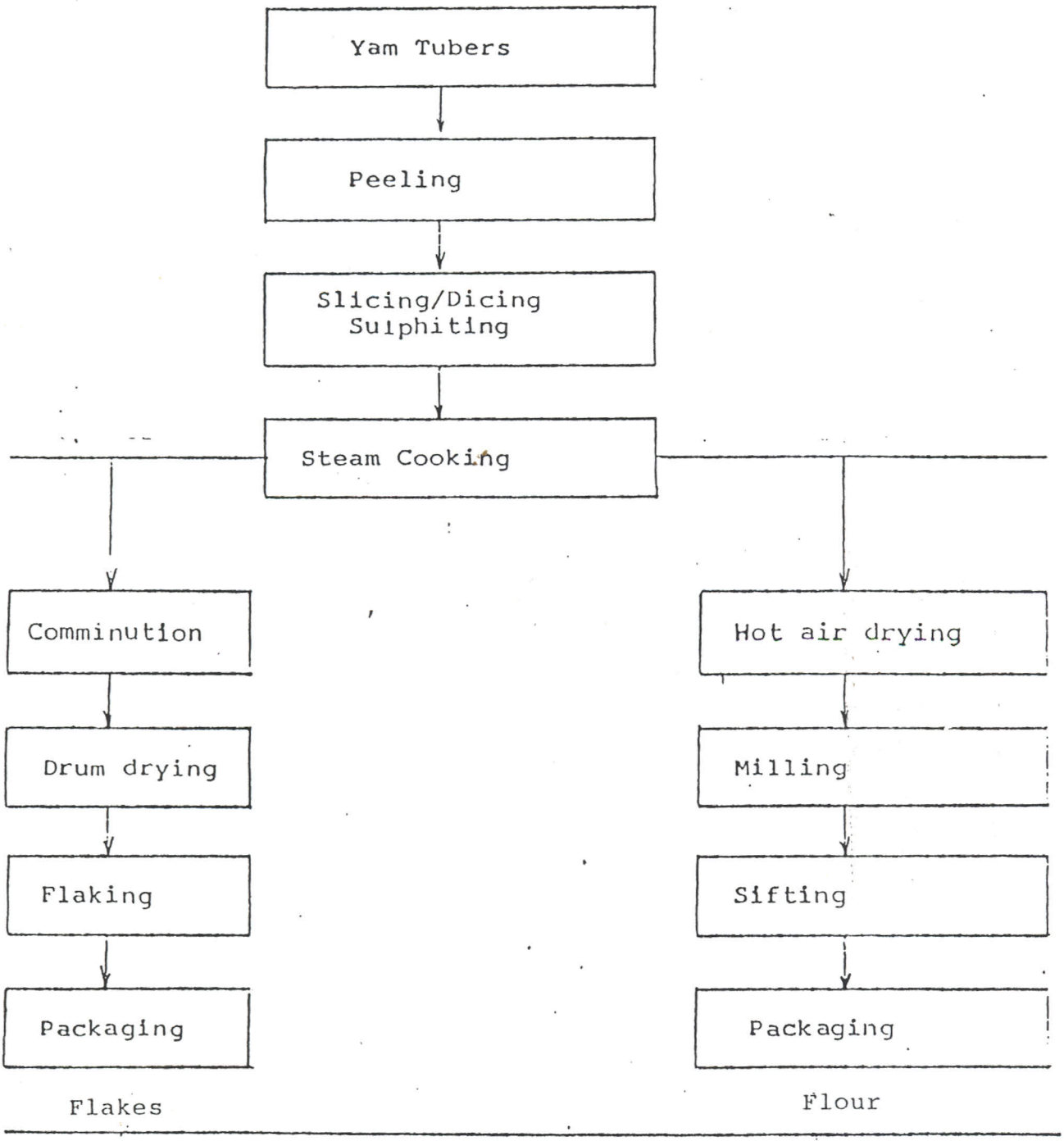
The recovery of starch is 18-20% of fresh cassava to 12 months old cassava. Cassava starch is difficult to promote in international market. Thailand is the only country participating in world trade, selling tropical starch. Japan is the largest buyer. West Germany, Netherlands, Belgium are main importers of dried cassava for animal feed.

Ghana grows cassava extensively but a single industry needs cassava of nearly 2000 tons per year. Raw material should be available at reasonable prices.

The Block farming, export or industrial village concept could promote the cassava starch industry.

Annex 13

Flow Diagram for the Production of Pre-gelatinized (Instant) Yam Flour/Flakes



Annex 14

ESTIMATED CAPITAL COST, OPERATING CONST. WORKING CAPITAL SALES AND PROFITABILITY FOR THE ESTABLISHMENT OF A VILLAGE LEVEL GARI PRODUCTION PLANT IN GHANA

		(3000kg/Week)	US Dollar
I.	Capital Investment		
1.01	Land, Buildg. Borehole, storage tank, Furniture		12,175.00
1.02	Process Equipment		6,525.00
		Sub Total	18,700.00
II.	Operating Cost		
2.01	Raw Materials		4,485.00
2.02	Operating supplies and utilities		3,347.375
2.03	Labour		3,600.00
2.04	Insurance		374.00
2.05	Repairs and Maintenance		561.00
2.06	Distribution cost		1,035.00
		Sub Total	13,404.375
2.07	Contigency 2%		268.06
2.08	Depreciation		802.5
		Total Operating Cost	14,474.9
III.	Estimated Working Capital (3 month's operating cost)		3,625.00
Iv.	Total Esimated Sales of gari		
4.01	Gari at ¢200/kg (34500kg/yr)		17,250.00
		Total Estimated sales cost	17,250.00

V. Net Estimated Profits

5.01 Profit per capital Investment = 14.8%
5.02 Profit per operating cost = 19.2%
5.03 Profit per working capital = 76.6%

SOME OPERATIONAL FIGURES

Cassava = 3000kg/week at US$ 0.0.325 per kg
Gari = 750kg/week at US$ 0.5 per month
Labour 10 personnel at US$ 30 per month
Operating period = 46 weeks per year.

List of Equipment

I. Peeling of the roots
1 large table with benches
10 Stainless steel knives

II. Washing peeled roots
1 large tiled trough of sandcrete blocks served with water via an inlet pipe and having drain outlet at the bottom.

III. Grating washed roots
1 Drum/Cylindrical grater
1 Lister diesel engine (8hp)

IV. Fermenting of grated roots
1 large tiled trough of sandcrete blocks

V. Dewatering of fermented mash
2 Vertically acting manually-operated screw press with housing and chute for juice discharge

VI. Sifting of dewatered mash
6 Bamboo cane sieves
6 Aluminium basins

VII. Roasting of sifted material
2 Integrated roasting bays with two stainless steel roasting pans and fired with fuelwood from outside and provided with a chimney.

VIII. Grinding of oversize gari granules and cassava dough
1 plate (attrition) mill size No. 2A (cornmill)

IX. Packaging
1 floor mounted weighing scale for weighing bulk products.
1 Heat sealer for sealing products packaged in plastic pouches.
1 Table top weighing scale
1 Wooden Table

X. Materials handling equipment
Baskets, enamel bowls, etc.

Annex 15

LIST OF ABBREVIATIONS

ACMVA	-	African Cassava Mosaic Virus Disease
AED	-	Agricultural Engineering Department
ATTC	-	Accra Technical Training Institute
CRI	-	Crops Research Institute
CSIR	-	Council for Scientific and Industrial Research
DA	-	District Assembly(ies)
DRHCI	-	Department of Rural Housing & Cottage Industries
DNFS	-	Department of Nutrition and Food Science
31 DWM	-	31st December Women's Movement
ESD	-	Extensions Services Department
FRI	-	Food REsearch Institute
GEPC	-	Ghana Export Promotions Council
GOG	-	Government of Ghana
GSB	-	Ghana Standards Board
GRATIS	-	Ghana Regional Appropriate Techn. Industrial Service
GWSC	-	Ghana Water and Sewerage Corporation
HCN	-	Hydrogen Cyanide
IFAD	-	International Fund for Agricultural Development
IITA	-	International Institute of Tropical Agriculture
MOE	-	Ministry of Education
MOEM	-	Ministry of Energy and Mines
MOFA	-	Ministry of Food and Agriculture
MOST	-	Ministry of Science and Technology
MOTI	-	Ministry of Trade and Industry
MTADP	-	Medium Term Agricultural Development Programme
NARP	-	National Agricultural Research Programme
NBSSI	-	National Board for Small Scale Industries
NCWD	-	National Council on Women and Development
NVTI	-	National Vocational Training Institute
PHDU	-	Post-Harvest Development Unit
SRDP	-	Small Holder Rehabilitation & Development Programme
TTC	-	Technology Transfer Centre
UG	-	University of Ghana
UNDP	-	United Nations Development Programme
UNIDO	-	United Nations Industrial Organisation
UST	-	University of Science and Technology
WHO	-	World Health Organization