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Sierra Leone.

ASSISTANCE FOR ESTABLISHING AND MANAGING A GARI-MAKING PILOT PLANT

REPUBLIC OF SIERRA LEONE

SI/SIL/82/803

CONSULTEC

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Sierra Leone.

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3749

FINAL REPORT

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

CONSULTEC

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02. SUMMARY

This report analyses the actual importance and future potencial of cassava in Sierra Leone and concludes that local government support of the cassava sector would very much help the economic development of the country. The production of cassava means:

a) food for the population;

b) employment;

c) economy of foreign currency, and

d) control of rice prices.

The actual agricultural practices used in the production of cassava in Sierra Leone are not suitable. The main problems being:

a) a large percentage of cassava plants are aflicted by the African Cassava Mosaic Virus;

b) the planting season does not coincide with the beginning of the rainy season;

c) cuttings are not selected;

d) weeding is carried out by hand (hoe) and many of times, not in the right period.

The report also analyses the cassava processing sector in spite of little information about the cassava market , and concludes that the technology used is very primitive.

At present, it is impossible to find local managers and skilled workers, able to run a sophisticated agroindustrial complex. Another problem refers to mechanical workshops which in this country are small or very small , and uncapable of manufacturing large and sophisticated machinery, equipment, and spare parts for both, processing plants and agriculture.

The report also suggests that the cassava processing

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demonstration plant should have the following characteristics:

a) small size, with a capacity of approximately 7.5 tons of cassava roots per day;

b) technology must not be so primitive but on the other hand must be simple, unsophisticated;

c) the demonstration plant will produce: gari, " foo - foo" starch, chips and "Too" .

Aside from the establishment of a cassava processing demonstration plant, training programs for the workers must be carried out, and the mechanical workshops must be improved.

03. TERMS OF REFERENCE AND MAIN ACTIVITIES OF THE MISSION

In accordance with the Terms of Reference SI/SIL/ 83 / 803 the objetives of our mission were:

a) to indicate to the government ways and means for establishing a cassava processing demonstration plant;

b) to define the best demonstration plant to be established and to indicate resources needed for its establishment.

Our professional carried out the following activities in Sierra Leone:

a) Briefing at UNDP office;

b) discussions with SIDFA, IDD & Ministry of Trade and Industry (MTI);

c) study of available reports;

d) visit to National Workshops;

e) travel to Tonkolili visiting the plant site and plantations;

f) visit to small gari units at Bo;

g) discussions with FAO and Ministry of Agriculture and Forestry (MAF);

h) visit to the Tikonko Agricultural Extension Centre at Bo;

i) travel to Pujehun to visit the Pujehun Rural Development Project;

j) technical discussions with IDD personnel on:

- selection of processes
- capacity of the industrial plant (Demonstration Unit)
- equipments
- layout
- selection of equipments and design for local production

k) presentation of observations and recommendations in a joint meeting UNIDO/MTI/MAF/SIDFA.

4. THE COUNTRY (see figure 1)

Sierra Leone has 73,326 square kilometers and a population of approximately 3.6 million with an annual growth rate of 2.9%. About 75% of the population lives in the rural area.

Sierra Leone has a great potencial for the development of agriculture, fisheries, agroindustries, mining and power plants. Compared to other African Countries, the soil is fertile and the wheather conditions are favourable for agriculture. Another asset is the fact that land is still cheap.

Economic growth in the past has been inadequate to absorb the growing labour force and this fact has contributed to high levels of unemployment and underemployment. However there is a shortage of skilled workers, not only in the industrial sector but also for educational programs.

The average "per capita" income declined during the past years and in 1983 Sierra Leone was included in the group of Under Developed Countries. The decline in the output of minerals and the violent increases in the cost of imported oil and manufactured products, together, deteriorated the balance of payments.

The main food in the national diet is rice. Cassava is the second in importance. The country is not self - sufficient in rice production, being a tradicional importer of that food[a] (see table 01).

Sierra Leone also imports, wheat grain and wheat flour (see table 02) as the country does not produce significant amount of that cereal.

Despite this, cereals and bread comprise the main item of the monthly "per capita" consumption expenditure on food (see table 03).

05. THE CASSAVA IN SIERRA LEONE

The last available statistics (see table 04) show that the country plants 16,200 hectares of cassava and produces 82,700 metric/tons of roots which a gives a yield of 5.1 tons per hectare.

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[a] In june 1984, the Japanese Government signed an agreement to provide Sierra Leone with a grant of 200 million yens by march 1985, to be used in the purchase of Thai rice.

According to the CIAT - Tropical Agriculture International Center (see figure 02) the potencial yield of cassava is approximately 90 tons of roots per hectare. Sierra Leone is well below average yields worldwide. The African Continent, for example, has a yield 25% greater than that of Sierra Leone (see table 05).

Land in Sierra Leone is still cheap and plentiful.Therefore in order to increase production, farmers normally increase the planted area and not the yield. Thus, as far as is known, in Sierra Leone the cassava planter does not apply basic agricultural practices directed to increasing yield, which would not be costly. For instance, planting in the right season, using selected cuttings, would not increase costs significantly.

Cassava is consumed in various ways in Sierra Leone. Boiled as a vegetable, it is eaten alone or palmoil, peanuts, fish or meat sauce is added.

"Foo-foo" is prepared from grated cassava which is boiled with a little water to give a thick paste. It is eaten with savoury sauces,palmoil and peanuts. (see figure 03)

"Too" is similar to "foo-foo" but is made from cassava flour prepared by peeling, chipping, sundrying and hand milling.

Grated cassava is often shaped into flat cakes and fried in palmoil. Alternatively, a stiff dough made from cassava flour and water, is shaped into flat cakes and baked into bread.

Sweet cassava cakes made with flour, sugar, baking powder, and banana are also popular (see figure 04).

Gari, a flour made by fermenting grated cassava tubers, semidextrinizing the mash by heat and finally drying the product, is eaten mainly in the South, East and North of the country (see figure 05).

Cassava starch is widely used to starch and iron clothes, with a flat iron. Besides, it is also used as human food (see figure 06).

The cassava leaves are also widely consumed in the form of fresh or boiled salad (see figure 07).

If cassava roots and products were to become an alternative food, this would avoid sharp price increases of rice when out of season.

The potencial market for cassava in Sierra Leone is very promising, due to:

a) the high population growth rate (2.9%);

b) the possibility in the near future, of using cassava for:

- paper finishing (using cassava starch) [b]
- textil finishing (using cassava starch) [c]
- composite flour (using starch or flour from cassava chips). It is possible to replace wheat flour by cassava starch or flour from cassava chips whithout any change in the final quality of bread, biscuits and macaroni as seen in table 06.

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[b] A UNIDO expert has established the feasibility of 20 t/day paper and board mill based on rice straw (80%) and imported wood pulp (20%). He did not favour the production of wood pulp locally because of the lack of homogeneity of the logs which can be extrated from the forests.
The Ministry of Agriculture and Forests has supported the project since the design of the pulp mill could be modified to enable production of wood pulp in future.

[c] Sierra Leone at present spends 12% of its total foreign currency earnings on the import of textiles to clothe its people. The annual consumption of cloth has been assessed at 22 million linear yards and, on this basis, the establishment of a large scale cotton-textile mill has been considered to be feasible by a UNIDO expert who carried out a study.

In addition, it is important to observe that in the last year a study was made in Sierra Leone to explore this possibility Report on Composite Flour Production Mission to Sierra Leone. October 26th until November 25th 1983,by Miss Joan Crabtree. Project TCP/SIL/2302 .

Thus,it is possible to conclude that Sierra Leonean Government's support of the cassava sector could improve significantly the economic development of the country, since resources from this sector could help to:

a) feed the population;

b) create employment;

c) save foreign-currency, and

d) stabilize rice market prices.

06. CASSAVA AGRICULTURAL SECTOR: PROBLEMS AND COMMENTARIES

At the present moment the cassava production systems used in Sierra Leone are not suitable for obtaining better productivity, a reduction of production costs or a increase in the farm's profits mainly because:

a) high percentage of cassava plants are ill, affected by African Cassava Mosaic Virus (see figure 08);

b) the planting time does not coincide with the beginning of the rainy season;

c) there is no selection of cuttings;

d) the weedings are made only by hand (hoe) and many of them not in the correct period.

COMMENTARIES: the plants from cuttings affected by the African Cassava Mosaic Virus suffer a significant decrease in productivity as we can observe in table 07.

TABLE 01: Sierra Leonean Imports of Rice.

YEAR	QUANTITY IN METRIC TONS
1970	49,365
1971	26,929
1972	6,668
1973	43,724
1974	45,035
1975	not available
1976	15,000
1977	6,700
1978	22,500
1979	76,536
1980	51,054
1981	54,246
1982	80,000

Source: Compiled by PEMSU from SLPMB's IMPORT FIGURES.

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TABLE 02· Sierra Leonean Imports of Wheat Grain and Wheat Flour in Flour Equivalent

YEAR	QUANTITY IMPORTED IN METRIC TONS
1970	23,558
1971	20,079
1972	22,850
1973	31,315
1974	25,766
1975	18,611
1976	21,331
1977	21,707
1978	21,719
1979	10,308
1980	20,440
1981	18,075

Source: Central Statistics Office
Compiled by PEMSU

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TABLE 03. Percentage Distribuition of Monthly "per capita" Consumption Expenditure on Food Items

FOODS AND OTHERS	%
Cereals, Bread............................	29.0
Starches and Starchy Roots..................	3.7
Sugar and Sweets............................	0.9
Pulses (Dry),Beans, Peas....................	0.8
Nuts..	1.8
Seeds.......................................	0.1
Vegetables and Potatoes.....................	7.7
Fruits Fresh and Dried......................	3.6
Meat, Meat Products, Poultry................	4.3
Eggs..	0.2
Fish, Shell Fish, Sea Food..................	8.5
Milk and Dairy Products.....................	1.1
Oils, Fats and Butter.......................	9.2
Salts.......................................	1.2
Other Foods.................................	0.2
Tea, Coffee etc.............................	0.3
Outside Meals...............................	1.7
Others (Spices,Yeast etc)...................	9.0
TOTAL FOOD	83.5
Soft Drinks.................................	0.4
Alcoholic Beverage..........................	2.5
Cigarettes, Tobacco etc.....................	13.5
TOTAL (FOOD, DRINK, TOBACCO)................	100.0

Source: Household Expenditure Survey June 76 - July 77

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TABLE 04: Planted Area and Cassava Roots Production in Sierra Leone

DISTRICT	AREA (ha)	PRODUCTION (TONS)
Southern Province	2,700	13,700
Bo	300	1,800
Bonthe	800	3,900
Moyamba	200	1,200
Pujehun	1,400	6,800
Eastern Province	1,500	8,700
Kailahun	100	1,000
Knema	600	3,700
Kono	800	4,000
Northern Province	10,900	54,600
Bombali	900	4,400
Kambia	1,800	9,400
Koinadugu	600	3,200
Port Loko	7,400	36,800
Tonkolili	200	800
Western Area	1,100	5,700
TOTAL	16,200	82,700

Source: Agricultural Statistical Survey

TABLE 05: World Cassava Yields, by Continents, Compared to Yields Obtained in Sierra Leone

CONTINENTS	AVERAGE YIELD*	(%)**
AFRICA......................	6.4	125
NORTH AND CENTRAL AMERICA...	6.0	118
SOUTH AMERICA...............	11.6	227
ASIA........................	11.7	229
OCEANIA.....................	11.0	216
WORLD.......................	8.9	175
SIERRA LEONE................	5.1	100

* SOURCE: FAO Production Yearbook Vol.36, 1982.

** Variation of cassava yields, compared to that of Sierra Leone (100%)

TABLE 06. Amount of Cassava Starch and Flour From Cassava Chips Required to Replace Wheat Flour in Baked and Pasta Products.

CASSAVA PRODUCTS	WHEAT FLOUR BAKED AND PASTA PRODUCTS		
	BREAD	BISCUITS	MACARONI
STARCH	30	40	20
CHIPS FLOUR	7	20	15

Source: Dr. Policarpo Vitti - Institute of Food Technology, (ITAL) Campinas, São Paulo, Brazil. (Personal Comunications).

TABLE 07. Mean Yield per Plant (in kilograms) of Plants Derived From Infected Cuttings with African Cassava Mosaic Virus and Healthy Cuttings.

TYPES OF CUTTINGS	CUTTINGS FROM VARIETIES "A"	CUTTINGS FROM VARIETIES "B"
HEALTHY	3.86	3.67
DISEASED	1.19	0.52
PERCENT LOSS	70	86

Source: Bock, K.R. and Guthrie, E.J. African Cassava Mosaic. Report an interdisciplinary workshop held at Muguga, Kenya, 19-22 February 1976. Editor: Barry L.Nestel. International Development Research Centre - IDRC - Bogotá, Colombia.

Furthermore, when the planting time does not coincide with the beginning of the rainy season the losses in yield can be high (see table 08).

TABLE 08. Planting Time and Productivity of Cassava Roots in Sete Lagoas, State of Minas Gerais, Brazil.

PLANTING TIME	PRODUCTIVITY OF ROOTS t/ha	YIELD VARIATION ACCORDING TO THE PLANTING SEASON (%)
AT THE BEGINNING OF THE RAINY SEASON	49.4	100
AT THE MIDDLE OF THE RAINY SEASON	21.4	43
AT THE END OF THE RAINY SEASON	1.6	3

Source: Correia, Hélio. Manejo da Cultura da Mandioca. Informe Agropecuário 5 (59/60): 16-29.1979. Belo Horizonte, Minas Gerais, Brasil.

Theoretically, it is possible to divide the cassava plant in three parts (see figure 09).

Planting made with cuttings from those different parts will result in different yields, sprouting time of the cuttings and starch content in the roots (see tables 9 and 10).

TABLE 09. Sprouting Time and Death of Cassava Plants from 100 Cuttings from the Different Parts of the Plant.

CUTTINGS FROM THE	DAYS AFTER PLANTING 13	19	26	33	PLANTS HARVESTED	SPROUT MAXIMUM	PLANTS THAT DIED AFTER SPROUTING
	SPROUT %				%	%	%
TOP	04	35	42	42	32	42	23.8
MIDDLE	23	71	86	86	78	86	9.3
BASE	23	88	96	96	92	96	4.1

Source: Mendes, Carlos Teixeira. Contribuição para o estudo da mandioca. Secretaria da Agricultura Indústria e Comércio do Estado de São Paulo, Brasil, 1940.

TABLE 10. Productivity of Cassava Roots and Starch Content of Plants from Different Types of Cuttings.

TYPE OF CUTTING	ROOTS t/ha	ROOTS STARCH CONTENT %	STARCH PRODUCTIVITY t/ha	STARCH PRODUCTIVITY Percentage (%)
TOP	9.9	29.7	2.94	100
MIDDLE	19.4	30.1	5.84	199
BASE	23.7	32.9	7.80	265

Source: Mendes, Carlos Teixeira. Contribuição para o estudo da mandioca. Secretaria da Agricultura Indústria e Comércio do Estado de São Paulo, Brasil. 1940.

TABLE 11. Weeding Season and Productivity of Cassava Roots.

WEEDING SEASON (DAYS AFTER PLANTING)	PRODUCTIVITY OF ROOTS t/ha	%
15 - 30 - 60 - 120	19.5	92
15 - 30 - 60 - 120 UH(*)	18.0	86
15 - 30 - 60	12.9	61
15 - 30	13.3	63
15	5.8	28
CONTROL (WITHOUT ANY WEEDING)	1.4	7
CONTROL (HERBICIDE WHEN NECESSARY)	21.2	100

(*) Until harvesting when required.

Source: CIAT - Centro Internacional de Agricultura Tropical & EMBRATER - Empresa Brasileira de Assistência Técnica e Extensão Rural, Manejo e Controle de Plantas Invasoras em Culturas de Mandioca. Guia de Estudo. 1982, Brasília, Brasil.

Therefore, it is an error to think that any cutting is suitable for planting.

The cassava crops must be free of weeds specially during the first four months after planting (critical period- see table 11).

Additionally, the first weedings should be made mechanically, using cultivators drawn by animals (see figure 10). Using that equipment the farmer will save time on the operation, besides being cheaper when compared with weeding by hand or by tractor (see table 12). The same animal used in the mechanical weeding, can also prepare the soil and transport farm products to the market.

TABLE 12. Cassava Crop Weeding. Comparative Time and Costs Among the Different Methods

WEEDING METHOD	AVERAGE TIME (MIN.) TO CULTIVATE ONE HECTARE	BRAZILIAN CURRENCY COSTS (Cr$)
BY HAND (HOE)	10,751	193.52
CULTIVATOR DRAWN BY ANIMAL	1,322	5.68
CULTIVATOR DRAWN BY TRACTOR	592	23.20

Source: Seixas, Braulio Luiz Sampaio et al. Teste preliminar em cultivos de mandioca. I Curso Intensivo Nacional de Mandioca EMBRAPA/CNPMF Cruz das Almas , Bahia, Brasil. 1976.

07. CASSAVA PROCESSING SECTOR: PROBLEMS AND COMMENTARIES

What does the Sierra Leonean cassava market require? This is the basic question we need to make, in order to produce cassava products with the desired characteristics. Unfortunately no answer could be found in Sierra Leone.

Another basic market question is: is it profitable to store cassava products? If so, when is the best season of the year to do this?

In Sierra Leone the present level of technology to process cassava roots is inadequate. The reasons are:

a) the roots are peeled by hand with knives and the peels and other residues from the roots are not used as animal feed (figure 11);

b) the roots are peeled in very small areas of the factory and the peels remain directly on the floor which is not coated (figure 11);

c) the roots are not cleaned before grating (figure 12);

d) the grating operation is made mainly by hand (manual graters) or more recently with motorized graters with circular wood wheels with perforated nail sheets and a sloped hopper (figure 13). In some of those graters the size relation between the pulleys from grater/engine is not adequate, resulting in a lower speed (r.p.m.) than that required by the grater (figure 14);

e) the raw grated roots are not sifted to remove root fibers before pressing;

f) the press operation is carried out in very primitive machines and the starch is seldom collected (figure 15);

g) the "cake" breaking operation is, at present, made by hand (figure 16);

h) the oven used today is very primitive and not adequate (figure 17):

- it has no furnace and chimney;
- the shape of the sheet is rectangular, containning dead corners;
- it is not located correctly in the factory;

i) the industrial building is, in general, very small, primitive and adapted from a house. In some places the different process operations are carried out in different sites (houses) around the main building;

j) the cassava chips are made by hand, helped by knives.

COMMENTARIES

The use of knifes to peel large amounts of cassava roots is not recommended since the operation time is longer than the mechanical peeling and the risk of accidents is increased.

An adequate site for the peeling sector (coated floor and size compatible to the number of workers) would provide several advantages: 1. a clear location; 2. an improvement in quality of the final products, and 3. an increase in labour productivity.

The perforated nail sheet is not the best equipment to grate properly the cassava roots. Especially if the target is starch production. In addition, the hopper used in Sierra Leone at present, is not adequate. As a consequence, the equipment efficiency decreases, and the workers are subject to a large risk of accidents.

The presence of fibers from the roots decrease the quality of the final products.

The critical point of cassava industrial plants in Sierra Leone is their pressing sectors, since the equipment is technically primitive. The consequence is an excessive operation time with implications in the quality of the final products.

In the pressing operation as carried out in Sierra Leonean plants a fermentation of the grated roots takes place for some products like gari and "foo-foo", some amount of fer mentation is desirable but it is important to observe that excessive fermentation time changes the quality (taste and flavor) of the final products with market consequences.

The "cake" breaking operation carried out by hand, takes a long time and contributes to decreased plant productivity.

For the drying sector to be efficient and effective it must:

a) have a furnace and chimney to decrease the quantity of smoke in the factory. This change will increase labour productivity as well as improve the fuel thermic efficiency (wood, in this case);

b) be properly located at the plant, to protect the workers and raw material from rain, wind and dirt brought by wind;

c) have an oven with a sheet adequately shaped in order to facilitate the workers job and to avoid burnning the product, which contributes to poor quality.

To dry and roast the gari, the worker puts it on the oven sheet and, helped by a wooden rake, moves the product from one side to another doing eliptical movements, trying to avoid the gari burnning. So, when the oven sheet is rectangular "dead corners" exist (places where the rake rarely touches, as can be seen in figure 18).

When the chipping operation is carried out by hand, the chips are thick and result in several inconveniences:

- long operation time to cut and to dry the chips;
- chips fermentation when drying, which affects product quality;
- larger sun drying areas (concrete yards) since the

moisture of thiker chips is higher and consequently the raw material must be spread out thinly.

In Sierra Leone the cassava starch is produced only as a by-product of gari and "foo-foo" during the pressing operation.

Taking into account the new alternatives to use cassava starch in that country in the near future (composite flour, and in paper and textil plants) it will be necessary to increase starch production. The present processing method is not suitable to attend to future demand. It will require substantial changes.

08. MANAGEMENT AND SKILLED WORKMEN FOR CASSAVA AGRICULTURAL AND PROCESSING SECTORS

Considering the country's situation with respect to the processing sector (very small and technically primitive cassava processing plants). Considering also that the country's cassava agricultural production system is far from reasonable compared to international standards, we conclude that it is not possible to find today in Sierra Leone managers and skilled workmen able to start and maintain a required cassava agroindustrial complex.

09. FACILITIES TO PRODUCE EQUIPMENTS, MACHINES AND SPARE PARTS FOR CASSAVA AGRICULTURAL AND PROCESSING SECTORS

All the workshops in Sierra Leone are small or very small, and at this moment they are not able to make large and sophisticated machines, equipment and spare parts for cassava agricultural and processing sectors (see figure 19).

On the other hand we think that the local workshops are able, at present, to produce small and not so sophisticated machines and equipments as they are already doing with some limitation (see figure 20).

We believe that if the Sierra Leonean workshops receive the necessary orientation (appropriate assistance) they would be able to improve their technical production level. As a consequence we are convinced they would lead to important changes in the country's cassava agricultural and processing sectors.

By gradually improving the quality of equipment produced by local workshops, we believe they will be able to produce in the future larger and more sophisticated machines and spare parts, that the development of the Sierra Leonean cassava agroindustry will require.

10. THE CASSAVA DEMONSTRATION UNIT

Considering that:

a) the present level of technology of the cassava agricultural and processing sectors in Sierra Leone is very low and inadequate;

b) the workshops in that country are able to make only small and unsophisticated machines and equipment;

c) it is impossible to find today in Sierra Leone managers and skilled workmen able to start and maintain a modern cassava agroindustrial complex;

d) the government of Sierra Leone has great interest in improving the present level of technology, using machines and equipment made in that country,

we conclude that the Cassava Demonstration Unit should have the following characteristics:

a) small size, processing about 7.5 metric tons of cas sava roots per day;

b) technology level higher than used at present but un sophisticated;

c) the factory size and the technology level should be improved gradually;

d) while the processing technical level is being improved the country could carry out an oriented personnel training and improve its workshop sector;

e) during some months the plant would work as an Observation or Test Unit, and after that time we believe it would be ready to be a Demonstration Unit;

f) the Demonstration Unit would be able to produce: gari, "foo-foo", starch, chips and "Too".

The Demonstration Unit should also be avaiable to be visited by people interested and at the same time to give all the necessary information on the industrial, administrative and financial sectors of the unit. The managers of the Demonstration Unit should reserve two days a month for these visits.

We recommend that the Demonstration Unit be installed at Robinki, Tonkolili District (figures 21 and 22),because:

a) there is a very small and primitive cassava processing plant that belongs to the Paramount Chief;

b) the Paramount Chief is very interested in increasing the amount produced and improving the cassava processing technical level;

c) Robinki is a cassava production zone;

d) the Paramount Chief has about 200 acres of cassava land.

In Sierra Leone there is no basic informations available about the cassava market. Therefore, we suggest that the government carry out studies to identify the characteristics of the cassava products desired by the consumers.In the studies, among other items, the following physical characteristics should be considered:

a) colour;

b) size of the grains;

c) acidity grade;

d) moisture content;

e) starch content;

f) ash content;

g) fiber content;

h) packing characteristics;

i) taste and flavor.

Price variations of cassava products should be studied in order to decide when to sell, whether immediately after processing or whether it is more advantageous to store and sell later.

10.1. DEMONSTRATION UNIT: AGRICULTURAL SECTOR

RECOMMENDATIONS

The Demonstration Unit shall also include the agricultural areas that will provide roots to the industrial plant.

From our experience in Brazil, we recommend that the plant must have, at least, two suppliers of raw material (roots):

a) the factory owner's crops;

b) independent suppliers crops.

The quantity of roots produced by the factory owner's crops should correspond to the break even point of the Demostration Unit. For instance, if the break even point is 45%, it is recommended that the factory owner's crops produce only 45% of the total industrial plant's capacity and the remainder 55% come from independent suppliers' crops.

All the independent suppliers should have a written contract signed with the factory stating the duties and rights of both parties.

It is also very important that all roads used to transport roots to the Demonstration Unit be preserved to save time and money.

The gratest economical and technical distance allowed to transport raw material from the cassava crops to the Demonstration Unit must be calculated using two parameters:

a) the raw material transportation cost;

b) the longest technical time admitted between the harvesting and processing of the roots (48 hours).

The factory must have a good expert group or at least an agriculture specialist able to:

a) research the cassava production costs;

b) choose the best farmers as suppliers of the Demonstration Unit;

c) supply the farmers with healthy and adequate cassava planting material;

d) solve raw material transportation problems;

e) inform the demonstration unit with respect to all the suppliers problems.

On the other hand, the government of Sierra Leone must provide one or two agronomists from the National Extension Service to assist the factory suppliers in cassava agricultural problems. For this purpose it is necessary that these agronomists be trained in modern cassava agricultural practices. We suggest that EMBRATER - Rural Brazilian Extension Service, a government sponsored agency, could be used for training these agronomists.

After studying the data collected by us at Robinki, Tonkolili District we recommend that:

a) it will be necessary to introduce in the country, as soon as possible, cassava varieties that, besides other advantages, are resistant to African Cassava Mosaic Virus. In Faranah, People's Republic of Guiné (country neighbouring Sierra Leone) there are cassava varieties from Tanzania that are resistant to that virus (see figure 23). We recommend that the government bring some cuttings of those varieties to Sierra Leone to study their behavior in the country's environment;

b) the rural extension service of Sierra Leone should carry out efforts to convince the cassava producers:

- to plant cassava only at the beginning of the rainy season;
- to make a correct selection of the cuttings;
- to weed the cassava crops only in the critical period and do the first weeding using cultivators drawn by animal;
- that in large areas, as the Paramount Chief has at Robinki, Tonkolili District, the cuttings manual preparation should be replaced by mechanically prepared cuttings (see Figure 24).

10.2. <u>DEMONSTRATION UNIT: PROCESSING SECTOR</u>

A. <u>CHOICE OF INDUSTRIAL PLANT SITE</u>

a) Be close to the suppliers of raw material in order to save money and time (cassava roots have about 65-70% of water content and most of that water is removed during processing);

b) be close to an abundant source of water, clean, not polluted and with a low iron content[d].

[d] To produce a very high quality starch it is recommended that the plant water has an iron content not above 0.2 ppm. If the water source does not conform to this specification a costly water treatment unit is required. If it is decided in the future to produce high quality starch at Robinki it should now be investigated whether the water source there available conforms to this specification. (See figure 25).

B. THE BUILDING (see figure 26).

a) the floor should be about 20 centimeters higher than ground level, to avoid the entrance of rain water in the building;

b) the floor should be coated and have about 1% of declivity to drain the water used to clean the Demonstration Unit;

c) the room height should be 3 meters;

d) roof
- eaves: 1.5 meters, to protect the workers and the raw material from rain and sun;
- cover: if possible use no inflammable material.

e) Walls: low walls or wooden fences,1.2 meters high, to prevent animals from entering the factory . The walls or fences must have a door with a spring for the entrance and exit of workers and also a gate for the entrance of raw material and exit of finished products.At the corners of the building where the ovens are located, it is recommended that the walls have maximum height to protect the workers and raw material from rain, wind and dirt brought by the wind. The high walls will also help the oven operator to do his job more easilly.

f) Size: in small factories, where the peeling operation is done by hand, the peeling sector should be about 33% of the total factory area, apart from the storage room. The proposed unit will be receiving 7,500 kilos of cassava roots per day, and considering that the average productivity of a trained worker in kilos of peeled cassava roots per day is 250 and that the ideal area required for each peeler is 3 square meters, the area of the Demonstration Unit must be 270 square meters (7,500 kilos divided by 250 kilos = 30 workers multiplied by 3 = 90 square meters (area of the peeling sector) multiplied by 3 = 270 square meters).

C. PEELING OPERATION

a) The knives used by the manual peeler shown in figure 27 should be replaced. This is cheap and simple to do, besides being safe and providing a better worker performance in the peeling operation;

b) use the skin as animal feed as[e]:

- the skin is a good food for many species of animal. Bovines for instance (see figure 28);

- the best cassava harvesting season coincides with the dry season when tre grass and herbage for animal feed is poor and of low quality;

- improve and diversify the income sources of the Demonstration Unit.

c) to improve the quality and the hygienic standard of the products from the cassava roots it is very important to also wash the roots after the peeling operation.

D. GRATING OPERATION

a) make a new model of grater consisting of:

- a wooden cylinder; (see figure 29)

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[e] "In North Western Province (Zambia), beer is made from the cassava peels after it has been dried and pounded. It is called Masangu or 7 days beer. This beer is also made in Luapula Province but not in Northern Province. Cassava is used in North Western Province to make gin called Lutuku. The distillation of this liquid is highly illegal, but widespread". Source: Atkinson, D.P. Wholey, D.J., Jarman, T.R.W. and Turnbull, J.(from Turnball of P.E International Operations Ltd and Ministry of U. K.). The concept for an integrated cassava processing factory for establishment in Zambia. UNIDO/IO/R.S1 28/ 1/83 US/INT/80/006.

- metal blade saw attached to the cylinder;
- protector belts to avoid accidents;
- a vertical hopper to avoid accidents and increase the grater productivity. This hopper must be provided with a drawer (see figure 30), to press the roots against the cylinder;
- the grater engine should be placed in the best position as shown in figure 31 to avoid accidents, to save space in the plant and improve the engine efficiency;
- the exaust pipe of the engine should be prolonged so that the silencer and the end of the exhaust pipe are on the roof of the processing plant. This system decreases the concentration of lethal gases (e.g. carbon monoxide) as well as reduces the noise in the factory;
- the speed of the grater should be about 1,800 rpm.

b) sift the raw grated roots to remove fibers. This will improve the quality of the final products (figure 32).

E. PRESSING OPERATION

a) make new models of presses[f] (see figures 33, 34, 35)

b) collect the starch on the tray under the press;

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[f] If better presses are introduced, the pressing operation will be faster and, consequently, fermentation conditions are changed. This may affect the taste and flavor of the gari and "foo-foo" and may cause a rejection of the product. If this problem occurs we suggest that:

a) the fermentation be carried out with grated roots before the pressing operation, as happens in the gari making plant in Faranah, People's Republic of Guine;

b) to decrease the time of fermentation we suggest adding some 3 day old cassava liquor collected in the presses, to the grated roots (see Annex 1).

c) break the "cake" (lumps) using sieves (figure 36).

F. DRYING OPERATION

a) make a new model consisting of:

- circular shape sheet; (see figure 37)
- furnace and chimney. The opening of the furnace must be outside and the chimney must have a heat adjuster;
- be situated in the corner of the building to protect the workers and the raw material from the rain and wind.

G. STORAGE

To preserve the cassava processed products for a lenght of time it is advisable that:

- the bags do not have direct contact with the storage room floor;
- plastic bags be used to avoid air moisture being absorved by the products;
- the roof of the storage room has no gutters;
- the products be dried until 10% of moisture content during processing;
- the products in the storage room be protected from insects and rats.

(Figure 38 shows a suggested storage room).

H. CHIPPING OPERATION

- build a cassava root chipper machine.
  It consists of a framework supporting a feed hopper and 27 inch diameter rotor disc. The framework is made of mild steel angle-iron and the hopper of mild steel plate welded and bolted together. Power drive is fed via a V-belt pulley. The prime mover is a 2 H.P. motor and the rotor disc is fitted with 4 corrugated chipping

blades. At least two persons are required to load the roots into the hopper and one more to clear the chips around the motor disc to avoid blocking the exit of fresh batches of chips.

In the equipmentthe disc should rotate at 580 rpm, which results in an approximate capacity of 2 tons of roots per hour and an extraction rate of chips of about 60%. At higher rotations the chips break,resulting in a lower extraction rate.

I. CHIPS DRYING OPERATION

The chips should be dried in the sun on the concrete yard using a density of 8 quilos of wet chips per square meter. The chips are ready to store when it is possible to use then as a chalk. It is possible to use the same method to dry the skins however with a product density of 4 quilos per square meter (see figures 39, 40,41 and 42.

J. STARCH PRODUCTION

Besides the traditional process[g] of producing cassava starch in Sierra Leone, we suggest that in the Demonstration Unit, the cassava starch be produced also directly from fresh roots.

In the next pages of this report, we present suggested process flow-sheets for production in the Demonstration Unit of cassava starch, gari, "foo-foo", "toc" and cassava chips.

10.3. DEMONSTRATION UNIT: MANAGEMENT, SKILLED WORKMEN, EQUIPMENT, MACHINES AND SPARE PARTS PRODUCTION

Brazil has a very heterogeneous cassava agro-industrial

(g) Starch is produced as a by-product from gari and "foo-foo" during the pressing operation.

sector because in the South and Southeast regions there are several large cassava processing plants, and the farmers cultivate cassava as a "cash-crop. On the other hand, in the other regions of the country, small cassava industrial units prevail and the farmers cultivate cassava as a subsistence crop.

To attend to all sector needs; Brazil has already an impressive industrial complex. These units are responsible for the production of machines and equipment for both small and large cassava processing plants.

In addition, the Brazilian Government can rely on intensive research and advice service for cassava agricultural problems.

Based on these observations we suggest that in the near future a Sierra Leonean mission composed of professionals from the agricultural, industrial and government sectors come to visit the Brazilian cassava agro-industrial sector. In Brazil, the mission could observe what has been done in that sector as well as to discuss directly with Brazilian professionals, eventual interchanges related to personnel training and possible technology transfer.

A. Existing Industrial unit in Robinki

The Industrial unit in Robinki, which belongs to the Paramount Chief is very primitive, like all other existing factories in Sierra Leone.
Therefore it is impossible to compare this unit with the proposed demonstration plant. Only three Gasoline ingines belonging to this factory can be used at the new plant.

B. Necessary equipment

The demonstration unit will require the following equipment:

a) 50 peelers, as shown in figure 27;

b) 03 graters as shown in figures 30 and 31.
Each grater will require a gasoline engine of 2.5 to

3.0 HP with a pulley speed of 3,000 rpm. The motor's pulley must have half the diameter of the grater's pulley in order to achieve a velocity of 1,800 rpm for the grater.

c) 06 presses chosen among the model shown in figures 33,34 and 35. Of the chosen model is that of figure 35 the hydraulic jack must have a capacity for 5 tons.

d) 04 ovens as indicated in figure 37.

e) 01 chipper

f) 02 equipments for preparing cassava cuttings as shown in figure 24. The motors used can be the same ones used for the graters.

C. Cost estimate of the necessary equipment in United States Dollars per unit (FOB Brazil)

a) peeler: US$2

b) engine (1): US$ 200

c) cylinder with knifes for the grater : US$ 30

d) <u>frame</u> of the grater : US$ 20

e) Press : US$ 200

f) Ovin : US$ 300

g) Chipper :US$ 600

h) Mechanical cassava cutter: US$ 50

i) This engine may be substituted by existing engines at the plant in Robinki.

11. CONCLUSIONS

Based on observations carried out during our field work in Sierra Leone, we conclude that:

1. At present, the cassava production systems used in Sierra Leone are not suitable for obtaining better productivity, a reduction of production costs or a increase in the farm's profits.

2. The country's present level of technology to process cassava roots is inadequate.

3. It is not possible to find today in Sierra Leone managers and skilled workmen able to start and mantain a required cassava agroindustrial complex.

4. The workshops in Sierra Leone, at this moment, are not able to make large and modern machines, equipment and spare parts for cassava agricultural and processing sectors.

   Additionally, we conclude that:

5. The potencial market for cassava in Sierra Leone is very promising, due to the high population growth rate (2.9%) and the possibility in the near future of using cassava starch for several ends. Among them, paper and textil finishing and composite flour.

6. The Government's support of the cassava sector,is essencial, since it could improve significantly the economic development of the country.Resources from this sector could help to: feed the population, create employment, save foreign-currency , and stabilize rice market prices.

7. The Sierra Leonean's support to the sector would include the establishment of a demonstration unit

at Robinki, Tonkolili District. But also the formulation and future execucion of policies related to the cassava agricultural and processing sectors as well as labor trainning and improvement of the local workshops.

8. The country has resources to reach the above mentioned goals. But it should also consider the technical support from other countries, including Brazil. For instance, personnel trainning in Brazilian Government sponsored agencies, and appropriate assistance to improve the technical level of Sierra Leonean cassava processing plants and workshops.

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FIGURES

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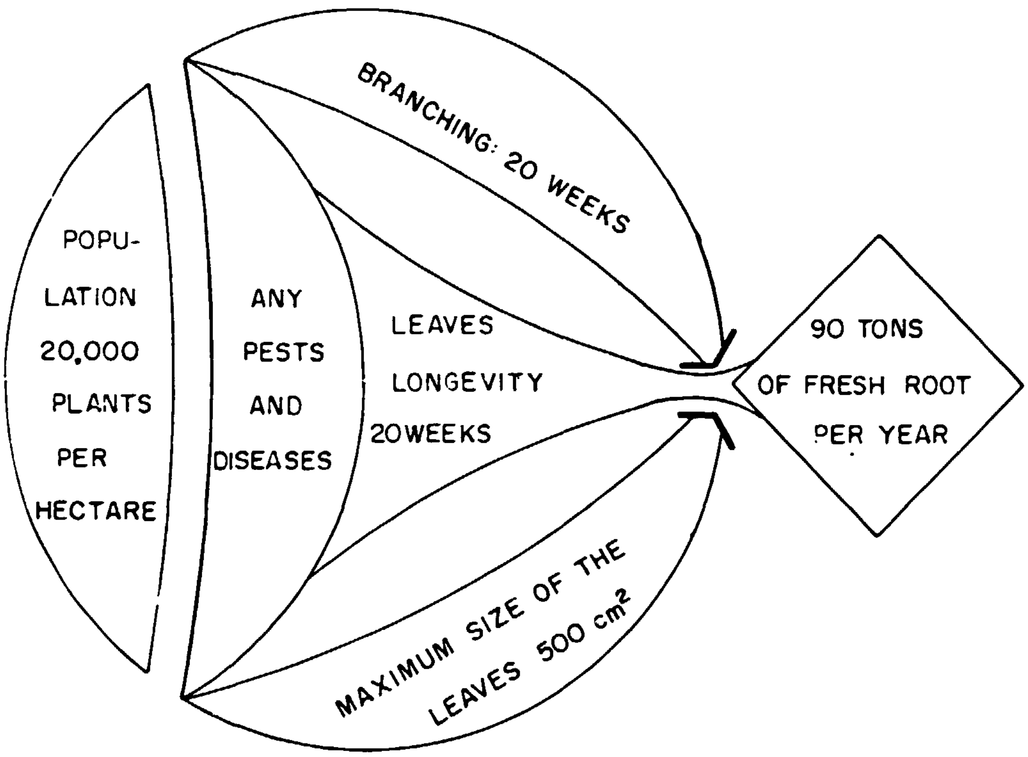
Figure 1. - MAP OF SIERRA LEONE



SOURCE: CIAT

Figure 2. - POTENCIAL PRODUCTIVITY OF CASSAVA

Figure 3. - "FOO-FOO" BEING TRADED AT FREETOWN

Figure 4. - SWEET CASSAVA CAKES BEING TRADED NEAR PUJEHUN

Figure 5. - GARI BEING TRADED NEAR BO

Figure 6. - CASSAVA STARCH BEING TRADED AT FREETOWN

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Figure 7. - CASSAVA LEAVES BEING TRADED AT BO

Figure 8. - CASSAVA PLANT AFFECTED BY AFRICAN CASSAVA MOSAIC VIRUS NEAR MAKENI

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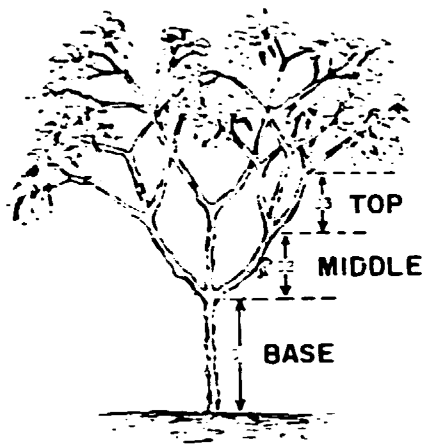

Figure 9. - CASSAVA PLANT AND ITS PARTS

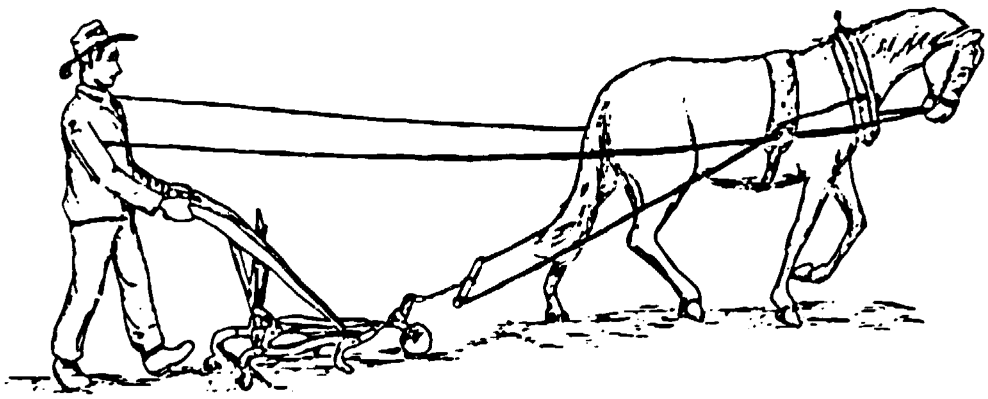

Figure 10. - CULTIVADOR DRAWN BY ANIMAL

Figure 11. - THE PEELING SECTOR OF A VERY SMALL GARI MAKING PLANT NEAR BO SHOWING THE ROOTS BEING PEELED BY HAND WITH HELP OF KNIVES

Figure 12. - DIRTY CASSAVA ROOTS READY TO BE GRATED

Figure 13. - NEW GRATER MODEL RECENTLY INTRODUCED IN SIERRA LEONE

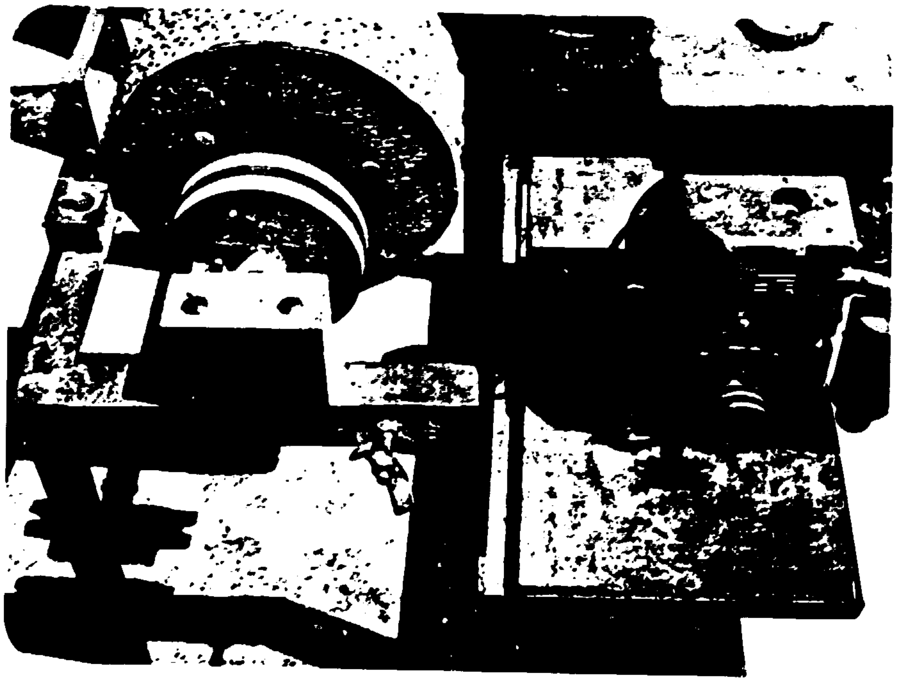

Figure 14. - GRATER AND ITS ENGINE SHOWING THE WRONG RELATION BETWEEN THE GRATER/ENGINE PULLEYS

Figure 15. - A VERY PRIMITIVE GARI PRESSING MACHINE USED IN A SMALL FACTORY NEAR BO

Figure 16. - THE "CAKE" OPERATION BEING CARRIED OUT BY HAND IN A SMALL FACTORY NEAR BO

Figure 17. - A RECTANGULAR OVEN FOUND IN A SMALL FACTORY NEAR BO

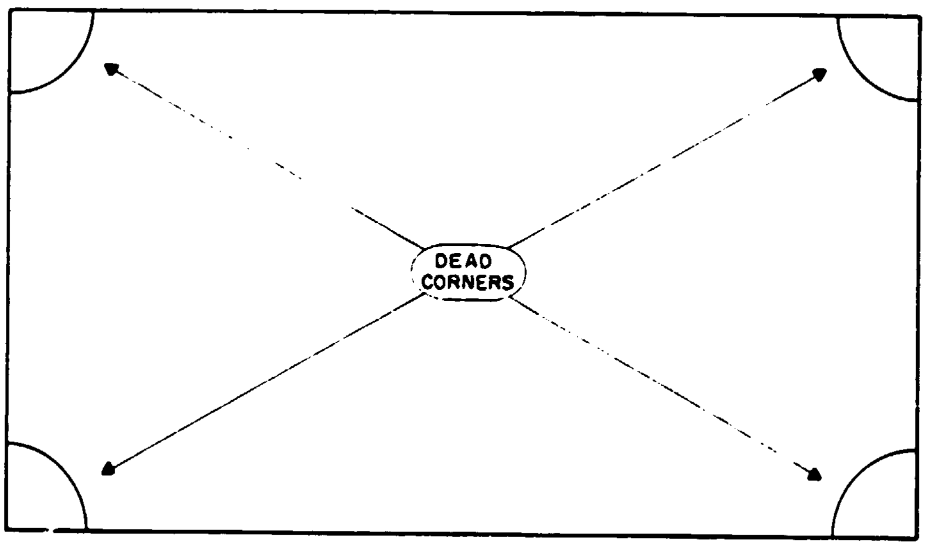

Figure 18. - THE "DEAD CORNER" PROBLEM IN THE RECTANGULAR SHAPE OVEN

Figure 19. *- A SMALL WORKSHOP AT THE TIKONKO AGRICULTURAL EXTENSION CENTRE AT BO*

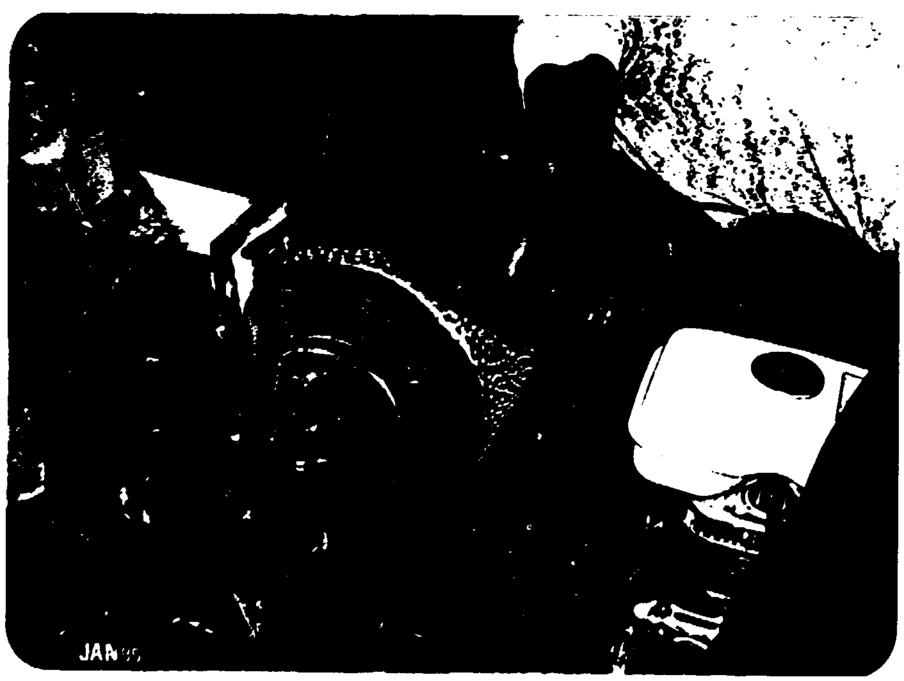

Figure 20. *- WORKER IN THE WORKSHOP OF TIKONKO AGRICULTURAL EXTENSION CENTRE AT BO MAKING A CASSAVA GRATER*

Figure 21. - GENERAL VIEW OF THE PLACE CHOSEN TO INSTALL THE DEMONSTRATION UNIT

Figure 22. - ANOTHER VIEW OF THE DEMOSTRATION UNIT SUGGESTED SITE

Figure 23. - PEOPLE'S REPUBLIC OF GUINE: CASSAVA PLANT FROM TANZANIA (RESISTANT TO AFRICAN CASSAVA MOSAIC VIRUS) ALONG SIDE OF ANOTHER CASSAVA PLANT FROM LOCAL VARIETY AFFECTED BY AFRICAN CASSAVA MOSAIC VIRUS

Figure 24. - MECHANICALLY PREPARED CASSAVA CUTTINGS - BRAZIL

Figure 25. - RIVER NEAR THE PLACE SUGGESTED TO INSTALL THE CASSAVA DEMONSTRATION UNIT

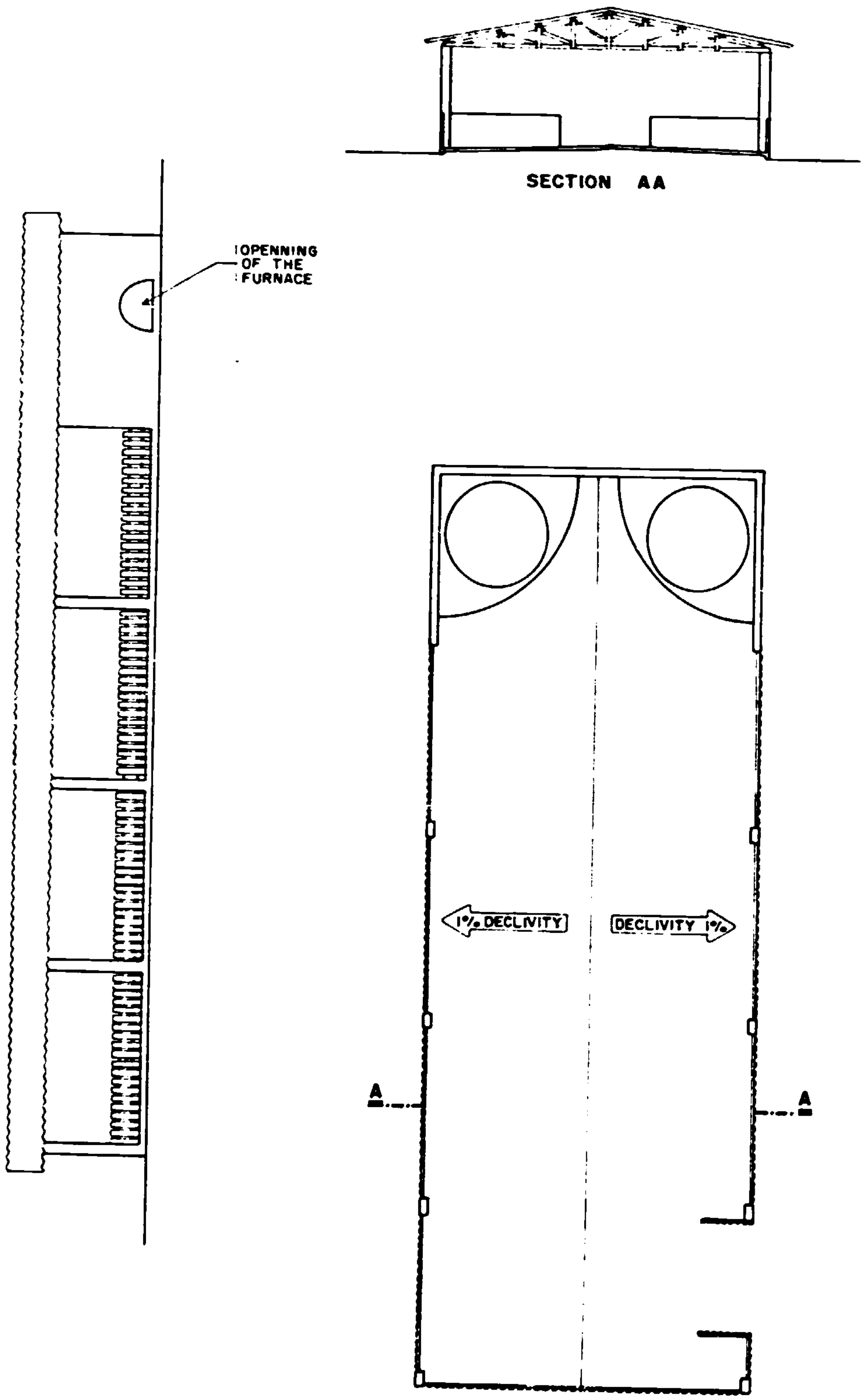

Figure 26 - SUGGESTED CASSAVA DEMONSTRATION UNIT PROCESSING BUILDING

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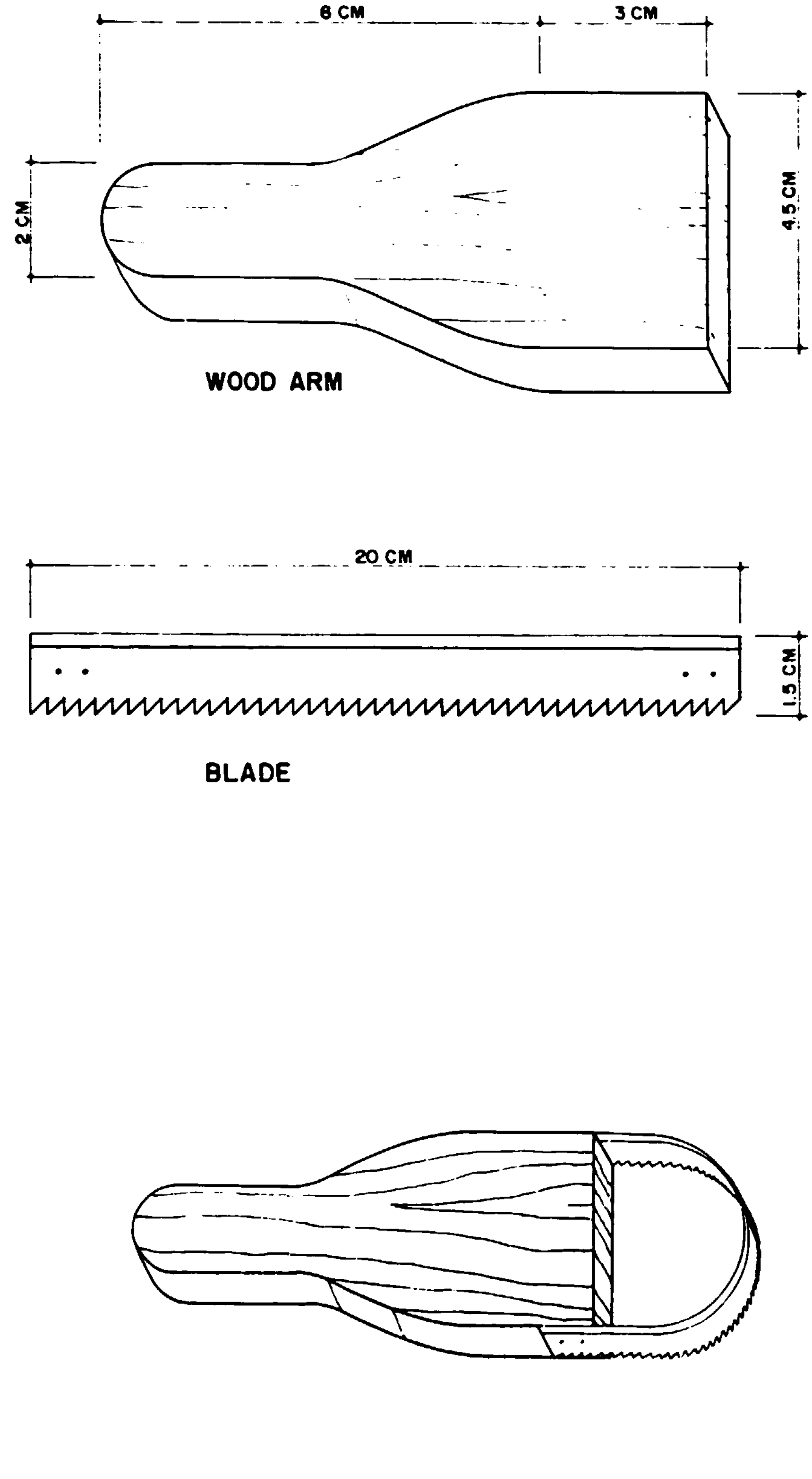

Figure 27. - MANUAL CASSAVA ROOTS PEELER

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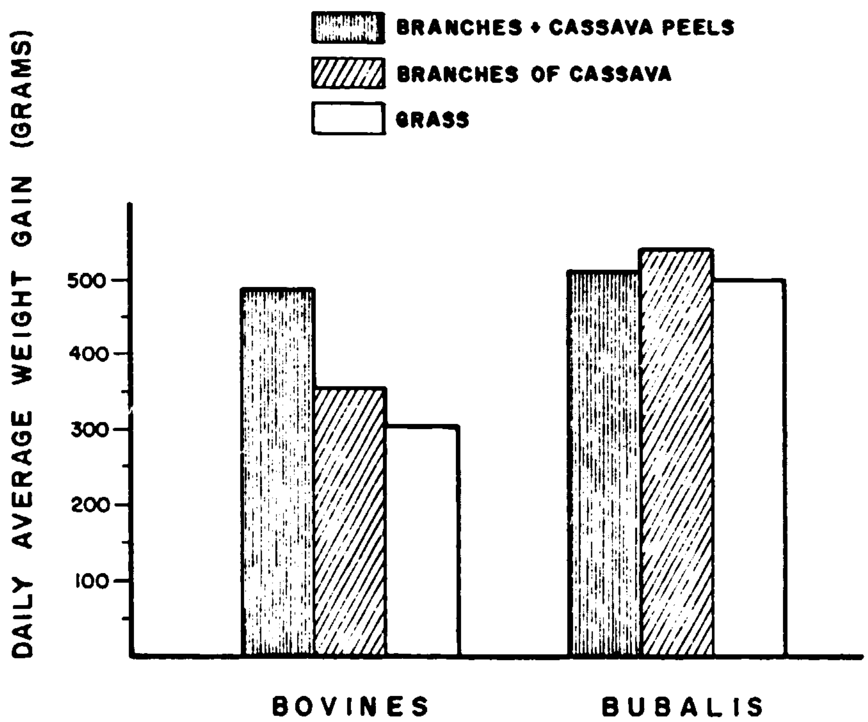


Figure 28. - CASSAVA AS ANIMAL FEED

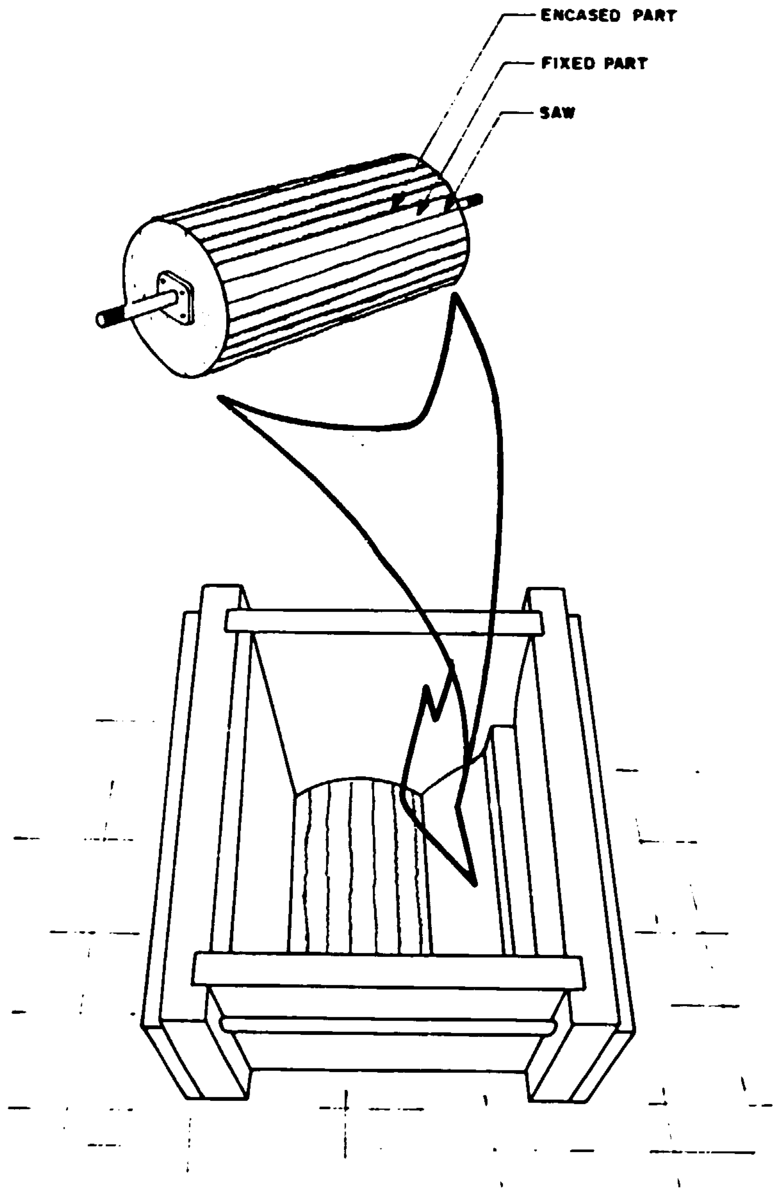


Figure 29. - CYLINDER GRATER

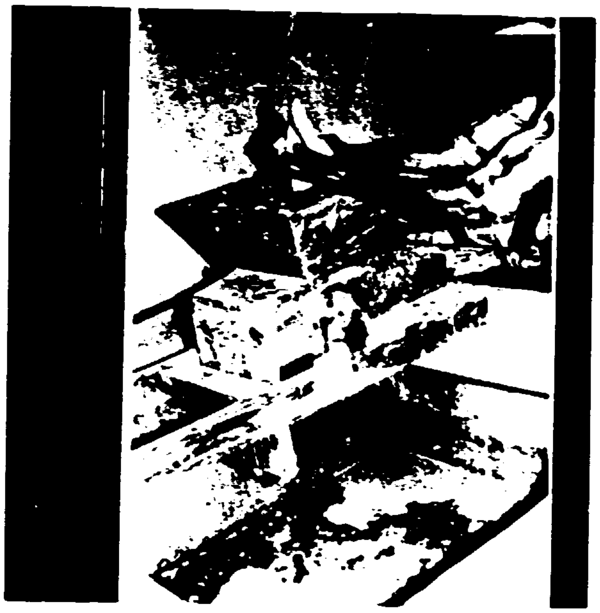


Figure 30. - A BRAZILIAN GRATER PROVIDED WITH VERTICAL HOPPER AND A DRAWER TO PRESS THE ROOTS AGAINST THE CYLINDER

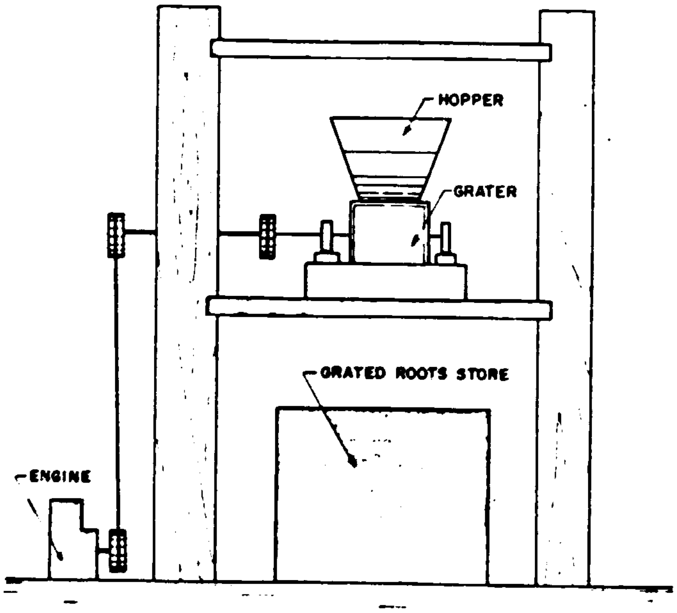


Figure 31 - ROOTS GRATER

Figure 32.- SIFTING THE RAW GRATED ROOTS TO REMOVE FIBERS

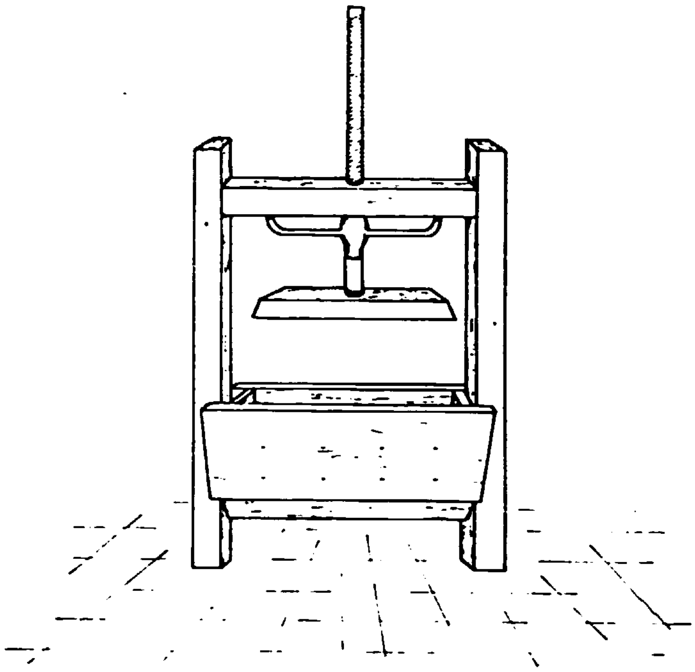


Figure 33 - CASSAVA PRESS MACHINE

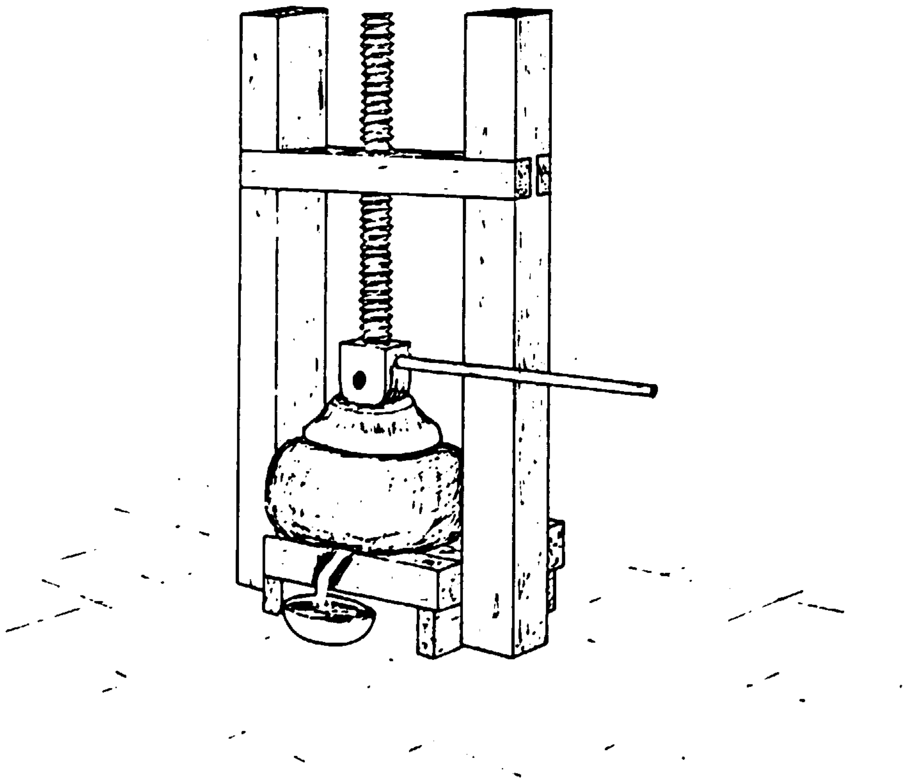


Figure 34. - CASSAVA PRESS MACHINE

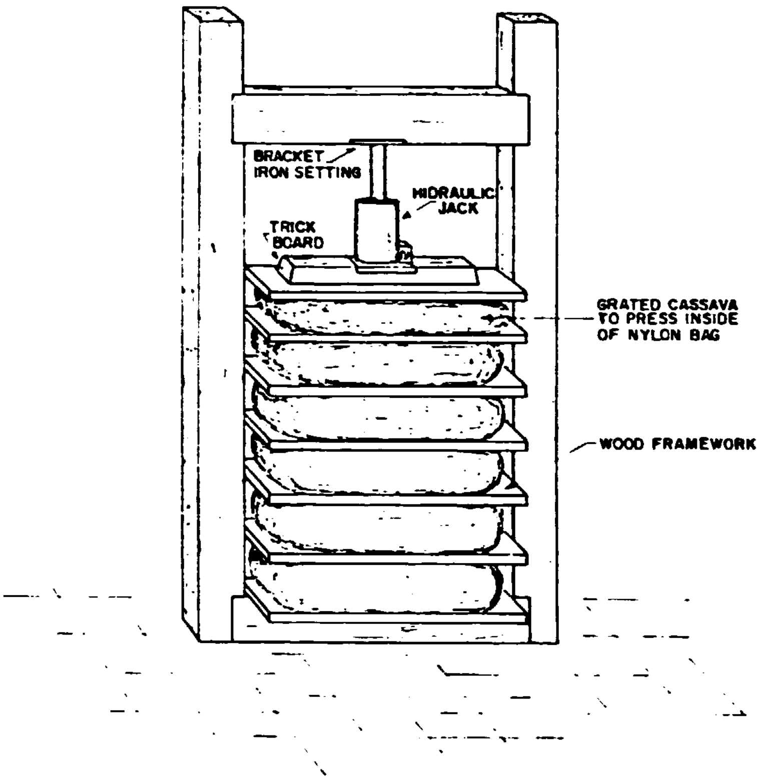


Figure 35 - CASSAVA JACK PRESS MACHINE

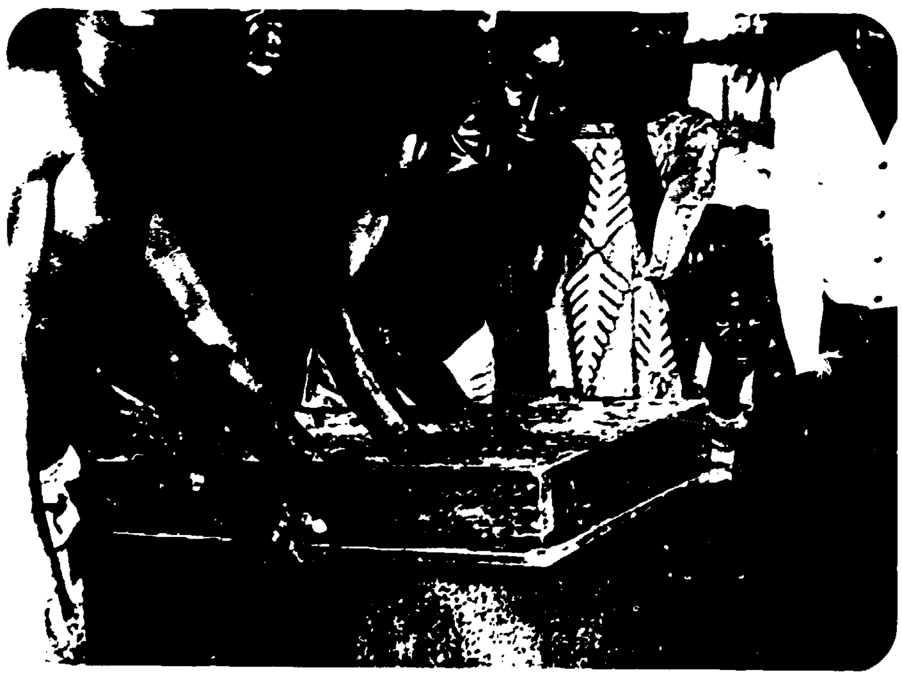


Figure 36 - A DEMONSTRATION NEAR BO: BREAKING THE "CAKE" WITH A SIEVE

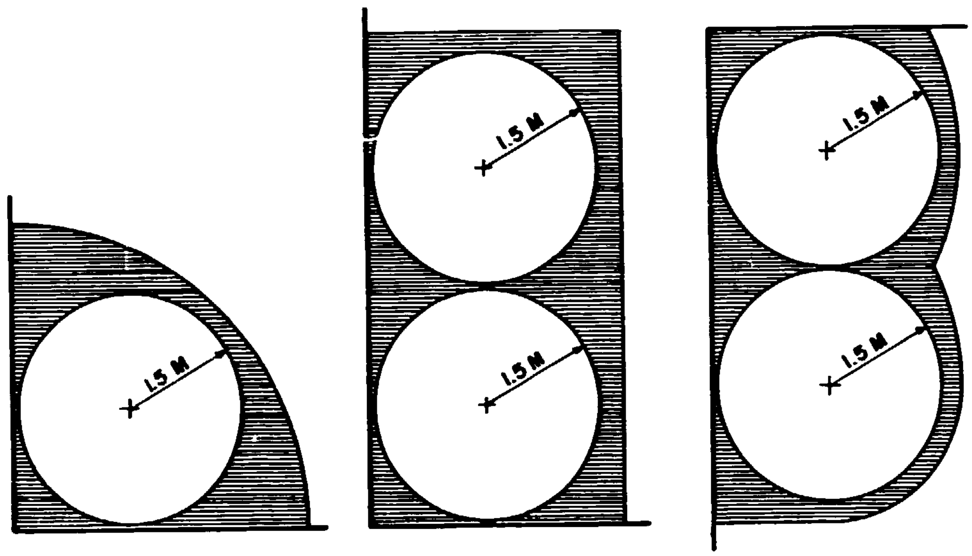


Figure 37 - DIFFERENT OVEN MODELS

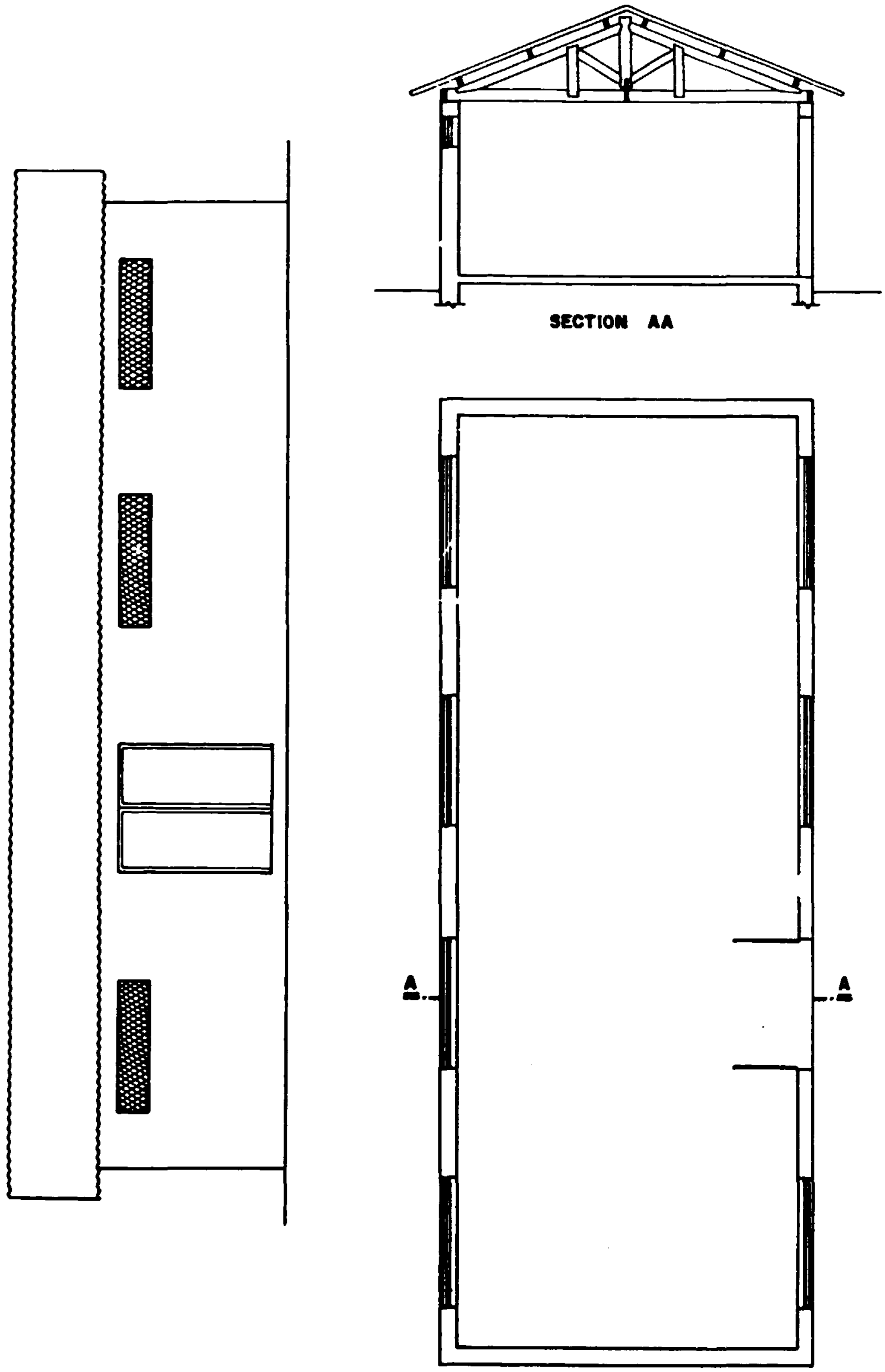


Figure 38 - STORAGE ROOM

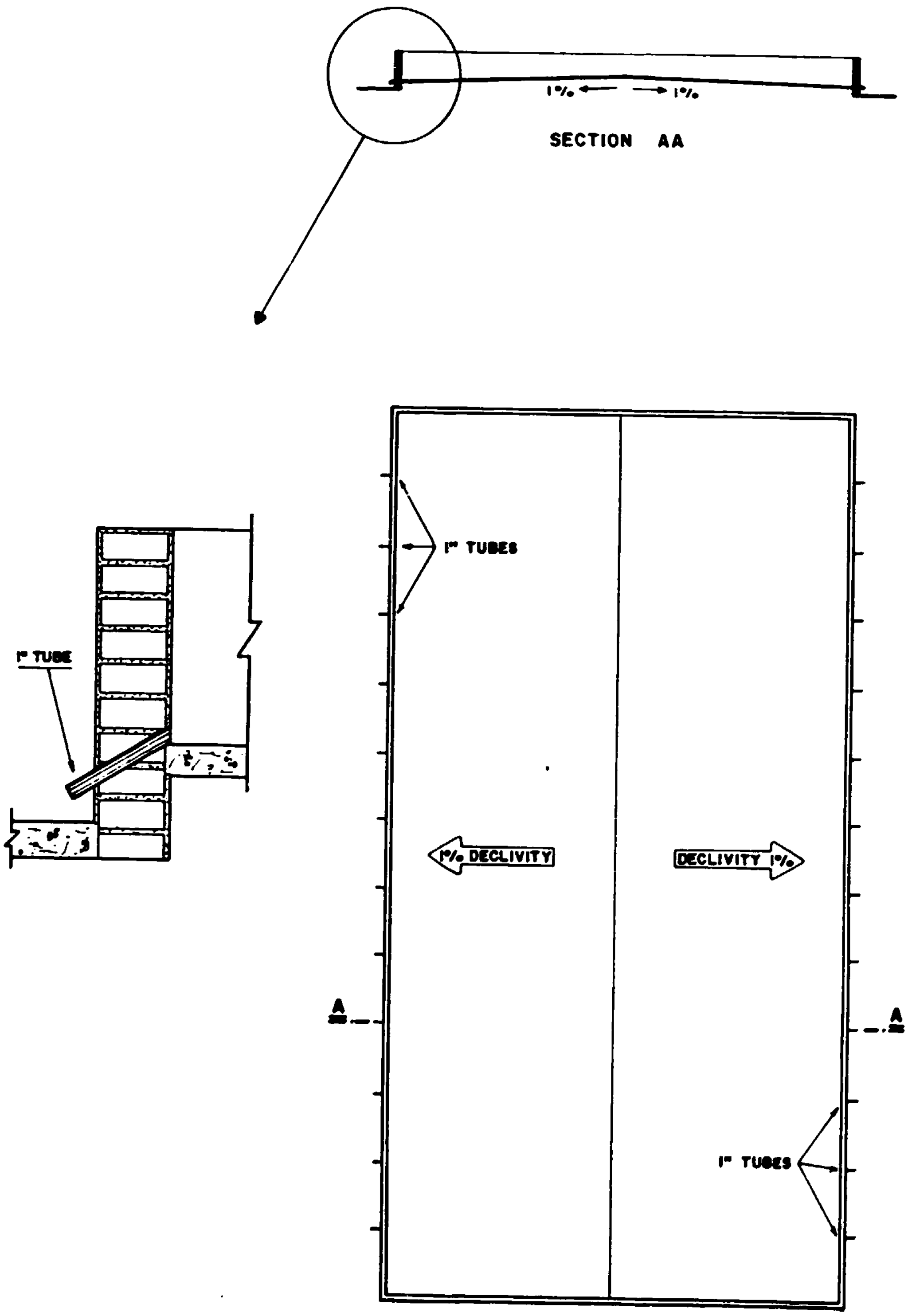


Figure 39. - CHIPS DRYING YARD

Figure 40. - WHEELBARROWS LOADED WITH WET CHIPS FOR DRYING

Figure 41. - SPREADING WET CASSAVA CHIPS ON THE CONCRETE YARD FOR DRYING IN THE SUN

Figure 42. - GENERAL VIEW OF A BRAZILIAN CONCRETE YARD FOR SUNDRYING CASSAVA CHIPS. IN THE BACK THE CASSAVA CHIPS STORAGE ROOM

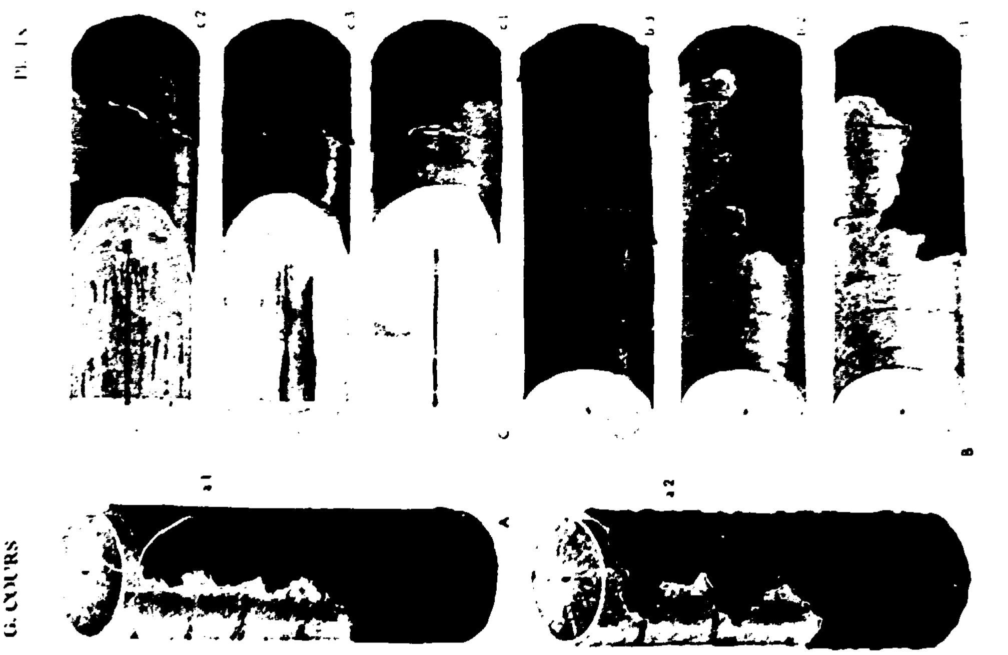
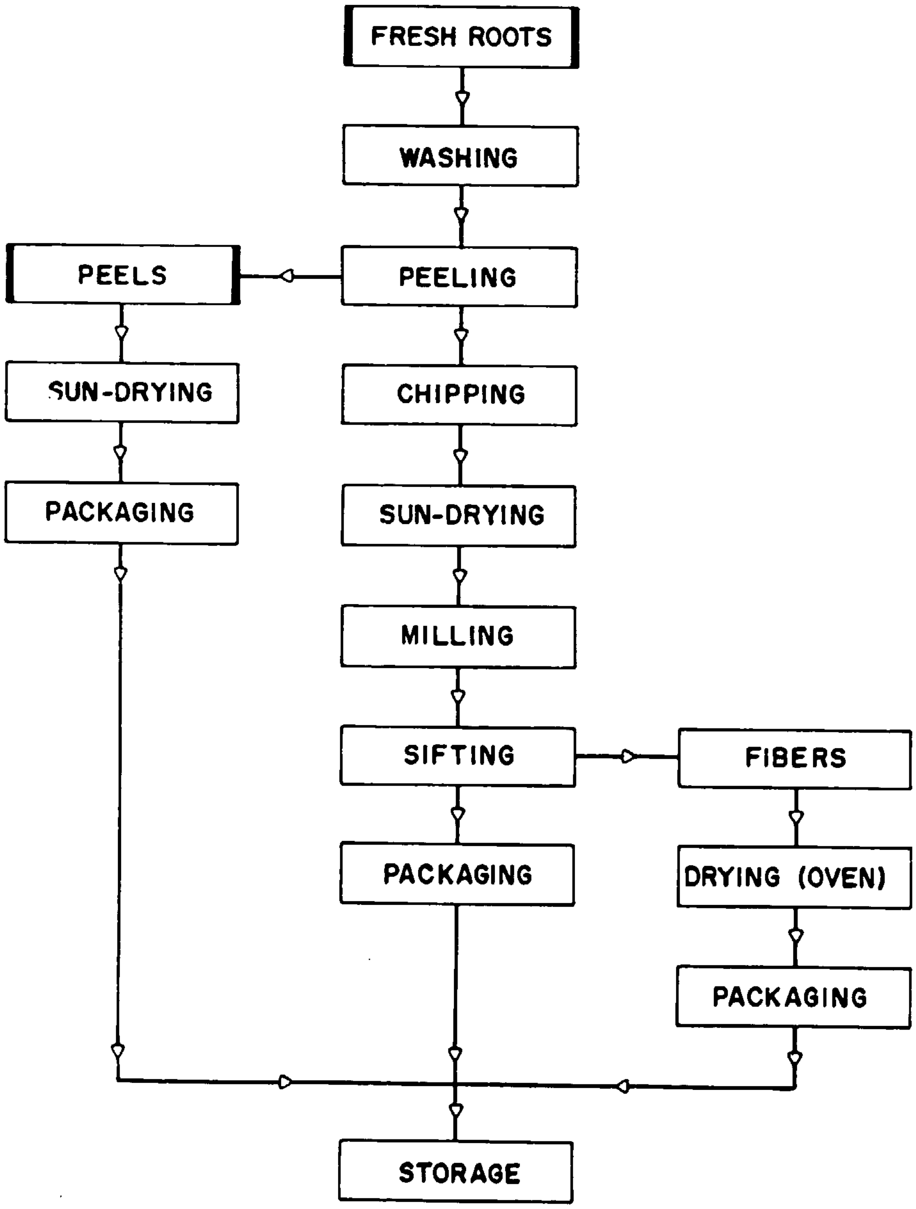


Figure 43. - A CASSAVA ROOT SHOWING THE OUTER PEEL, THE INNER PEEL AND THE PULP

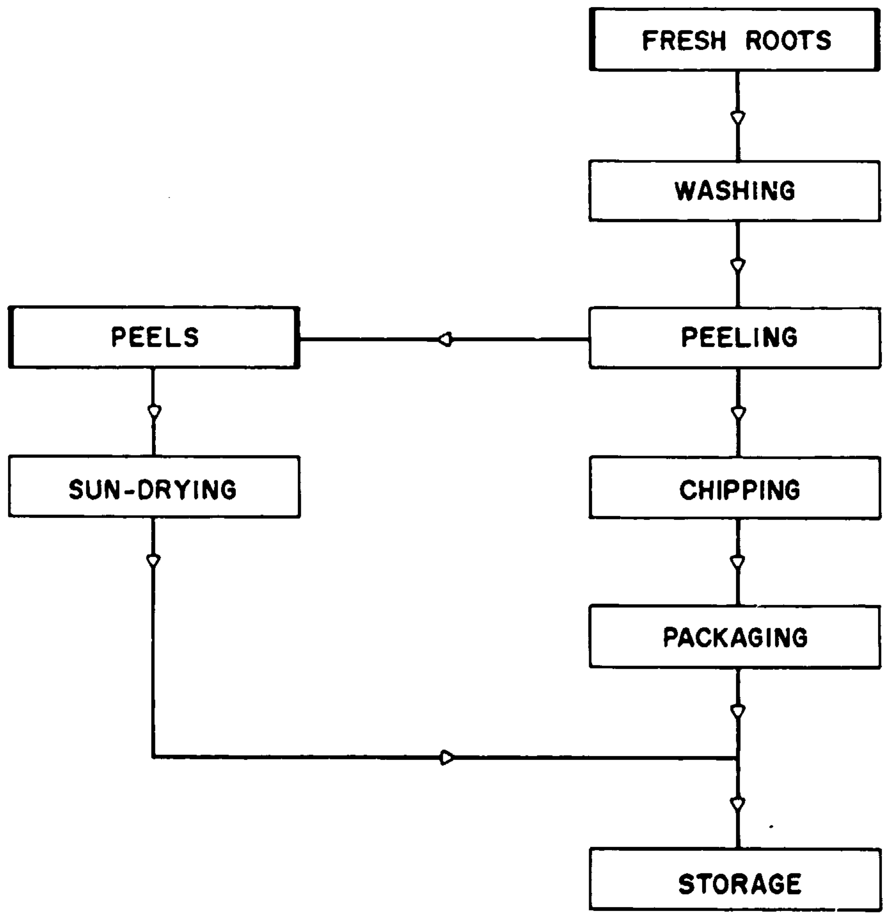
PROPOSED FLOW-SHEET FOR PRODUCTION OF

"TOO"



PROPOSED FLOW-SHEET FOR PRODUCTION OF

CASSAVA CHIPS



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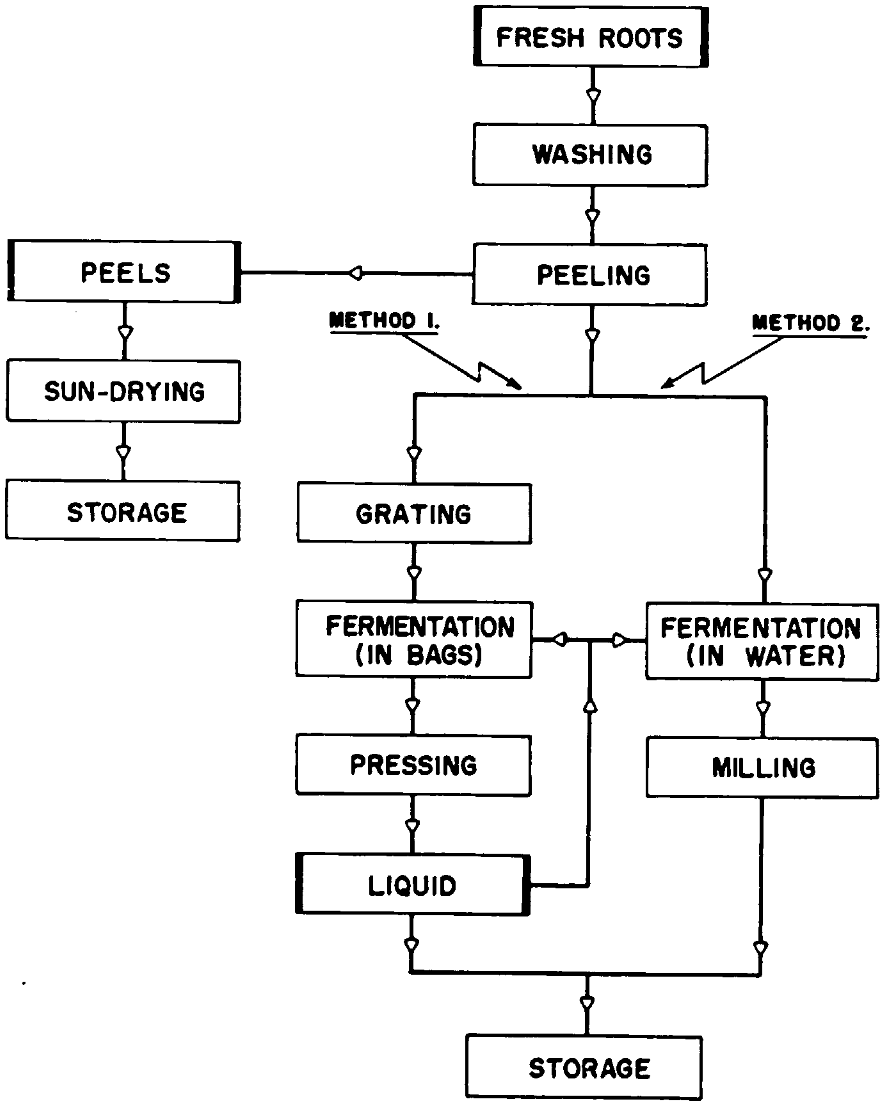
PROPOSED FLOW-SHEET FOR PRODUCTION OF "FOO-FOO"



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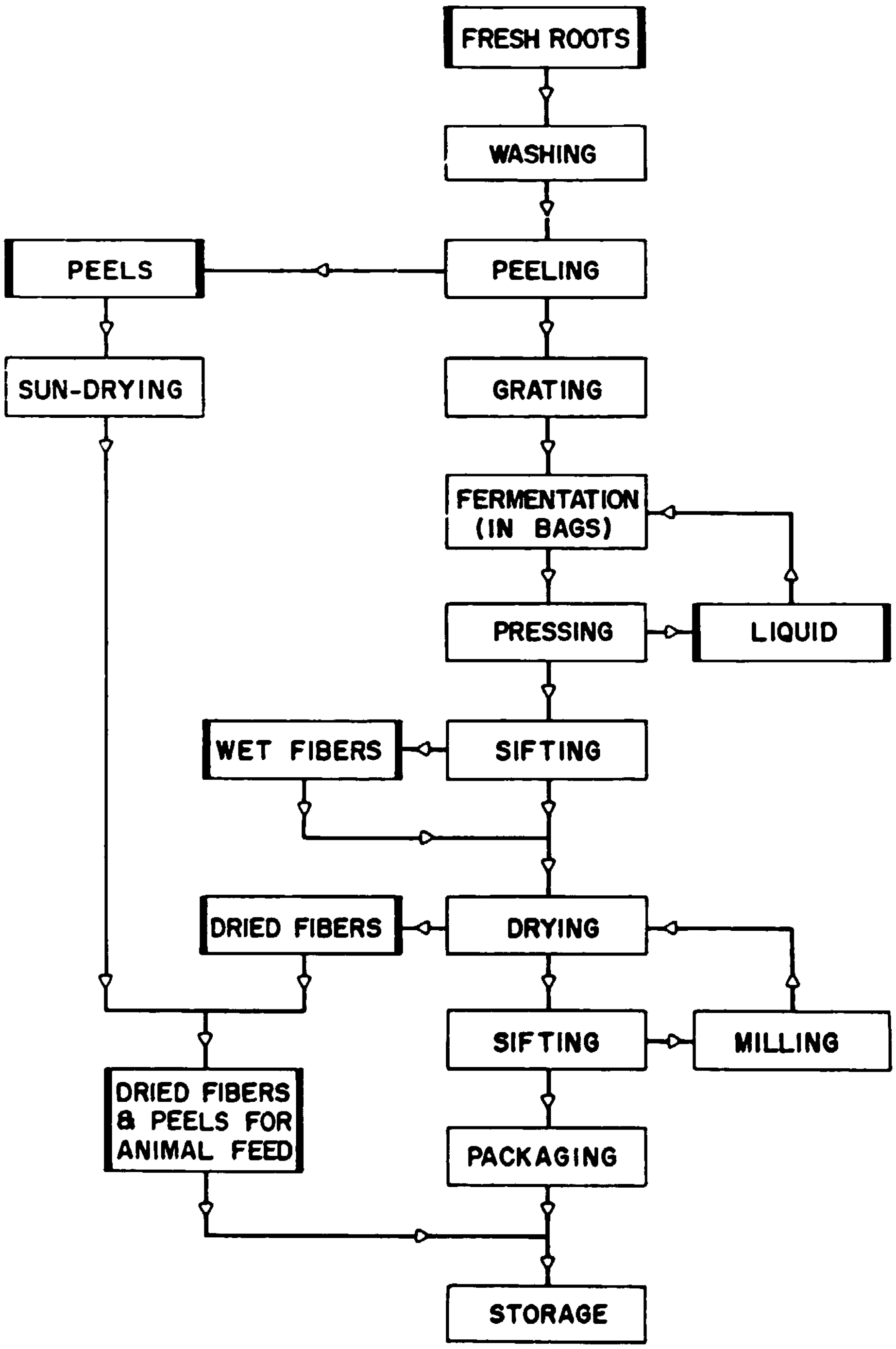
PROPOSED FLOW-SHEET FOR PRODUCTION OF GARI



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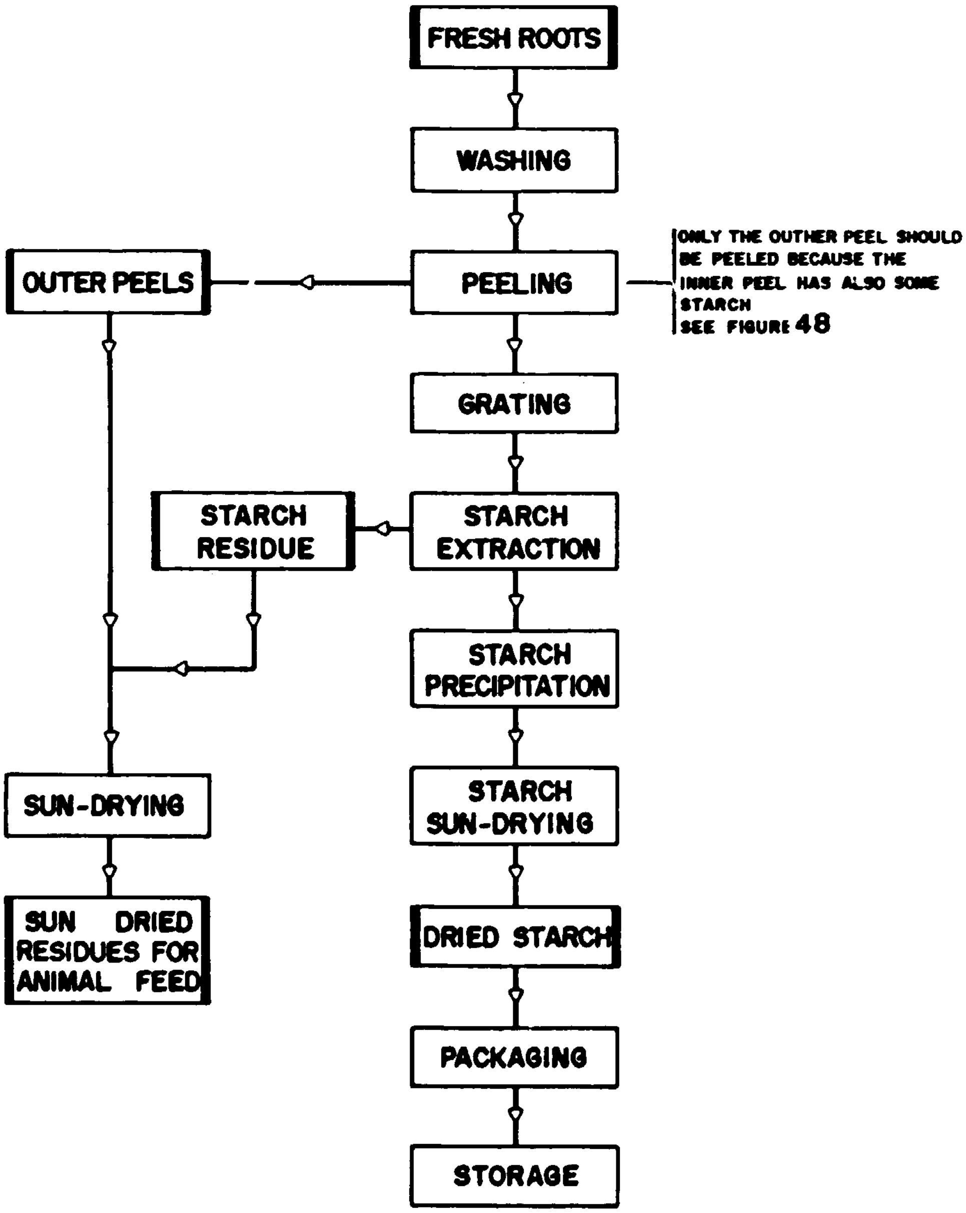
PROPOSED FLOW-SHEET FOR PRODUCTION OF CASSAVA STARCH



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ANNEX 1

AN IMPROVED TECHNIQUE OF PROCESSING CASSAVA FUFU

FESTUS A. NUMFOR[1]

In tropical Africa, the preparation of fufu involves soaking (fermenting) peeled cassava roots for 3–5 days, mashing, sun-drying the pulp for 2–4 days, and milling into flour (2% protein). An attempt was made to improve on this time-consuming process and on the nutritional value of the product. Peeled roots were grated before being soaked, the result being that fermentation proceeded much faster than with the whole root. When the grated pulp was inoculated with 3-day-old cassava liquor, the fermentation time was [illegible] and a simply designed solar/fire dryer reduced drying time substantially. The nutritional value was improved to 6% protein by the addition of full-fat soybean flour (10% of total weight). The product was not significantly different ($P < 0.05$) organoleptically from the unenriched flour.

Fufu — fermented cassava flour — is consumed in West and Central Africa as far south as Angola and as far east as Madagascar. The roots are peeled, washed, steeped in water for 3–5 days until soft, pressed into pulp, sun-dried for 2–4 days, and then milled into flour. The steps, as in other traditional methods for cassava preparation, are aimed at reducing to innocuous levels the concentrations of toxic linamarin present naturally in the cassava roots. Unfortunately, fufu, as processed traditionally, is time-consuming (3–5 days' fermentation and 2–4 days' sun drying). There is usually exposure of the pulp to contamination during soaking and drying. Variability in yields, products that are not standardized, and lack of appropriate packaging have discouraged industrial processing.

This report describes studies to modify the process to give a more hygienic, nutritious, and standard product through reduction of fermentation and drying times; improvement of drying conditions; protein enrichment; and packaging.

MATERIALS AND METHODS

Cassava roots were peeled, washed, and divided into portions, 8 kg each. Those in the first group were left whole; those in the second and third groups were cut into 5- and 2-cm discs, respectively; and those in the fourth group were grated by hand. Each group was divided in half and steeped in 5 L tapwater or 3-day-old cassava liquor and allowed to ferment naturally. The liquor, 25 mL, was sampled immediately and every 24 h until the roots became soft. The acidity of the sampled liquor was determined by titration with 0.1N sodium hydroxide. The acidity was plotted against time for each group.

A simple, double-effect (solar/fire) dryer was designed, constructed, and compared with a laboratory oven, a Roucadil ventilated chamber, and sun drying.

Soybean was chosen for supplementation because of its high protein content, availability, and novelty.

A simple technique was designed to produce full-fat soybean flour with minimal enzymatic activity. The steps involved washing the beans, soaking them 5 h, removing the hulls, steaming 20 minutes, drying, and milling.

Samples of fufu were enriched with the flour at 0, 5, 10, 15, and 20% of total weight. Fufu paste was prepared (traditional method) from these composite flours and their organoleptic properties compared by a taste panel (accustomed to fufu eating) of nine. At 10% level of substitution, there was no significant organoleptic difference ($P < 0.05$) between the composite and the unenriched flour. These promising results prompted a larger taste test: 55 households were chosen in the Western Province of Cameroon, and each participant was given 1 kg of the enriched fufu sample, packaged in a transparent polyethylene bag; asked to prepare it the usual

[1] Institute of Agronomic Research, Njombe, Cameroon

Table [illegible]. Some major characteristics of four systems for drying cassava pulp

System	Capacity (kg of pulp)	Drying temperature (°C)	Time (h)	Cost ([illegible])
Lequeux laboratory oven	[illegible]	[illegible]	24	[illegible]
Roucadil ventilated chamber	[illegible]	[illegible]	10	[illegible]
Double-effect dryer	[illegible]	[illegible]	28	150
Open sun drying	Infinite	[illegible]	96	—

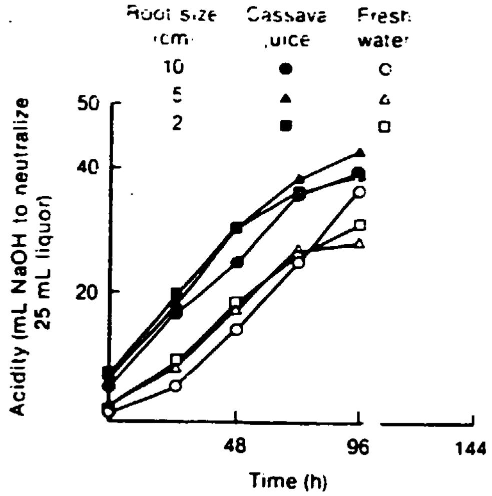

Fig. 1. *Effect of root size and medium (cassava juice or fresh water) on cassava fermentation*

way; taste it; and complete a questionnaire accompanying the sample.

Proximate analysis was carried out to compare the enriched and unenriched fufu. The samples were oven-dried at 105°C for 5 h for moisture determination, and the Kjeldahl method was used to determine the protein content. Total lipids were determined by the Soxhlet method, and the level of cyanide was assessed by the silver nitrate volumetric method.

Results and Discussion

The rate of fermentation (development of acidity) increased with increased reduction in size of the roots. Grating enhanced contact between linamarase and linamarin so that most of the cyanogenic glucoside in the grated sample was hydrolyzed quickly to hydrocyanic acid. It also increased the surface area of the medium and made the nutrients more readily available to the microorganisms causing fermentation. In the traditional method, the roots take 4 days to soften, whereas the grated pulp ferments in about 48 h.

The microflora responsible for cassava fermentation are indigenous to the roots. Levi and Collard (1959) identified *Corynebacterium manihot* and *Geotricum candida* as the microorganisms involved in a related process — gari manufacture. Recently, Okafor (1977) questioned the validity of Levi and Collard's results, as he was unable to isolate *Corynebacterium* sp in appreciable quantities from fermenting cassava. Consequently, Ngaba and Lee (1979) have isolated and identified *Lactobacillus* sp and *Streptococcus* sp. as responsible for the acidity and flavour.

Because the processing of fufu involves fermenting a liquid rather than a solid, as in gari manufacture, the microflora involved are probably different. This possibility is under investigation.

In a related study, Akinrele (1964) showed that, when fresh cassava pulp was seeded with 4-day-old juice, the fermentation took 24 h. Our results confirmed this earlier work (Fig. 1). Instead of steeping whole roots in water, one could reduce process time considerably by pulping them and seeding them with 3-day-old liquor.

Drying the fufu with the laboratory oven or the Roucadil ventilated chamber proved very efficient, but the cost (Table 1) would be prohibitive for village-level processing. The simple solar/fire dryer reduced drying time to 24 h from the 72-96 h common with sun drying. It also eliminated contamination.

The product was rated very good or better (extremely good, excellent) by about 70% of the respondents from 55 households in Western Province, and more than 60% felt it was easy to prepare. Although 60% stated that the product was equal or superior to traditional fufu, 40% felt it was not white enough. Taste was judged to be the most appealing characteristic, and colour was considered the least attractive feature. The proximate analysis of improved (enriched and processed quickly) fufu showed protein 5.50%, lipids 3.30%, starch 79.6%, and soluble sugar 1.26%. The corresponding values for fufu processed traditionally were 1.54%, 0.77%, 82% and nil. The HCN (mg/kg) was 30.7 for the improved and 19.6 for the traditional.

The time used for traditional processing of fufu was considerably reduced when the tubers were comminuted before fermentation and seeded with 3-day-old cassava liquor, and a cheap and simply constructed double-effect dryer reduced considerably the drying time. Finally the protein content was increased substantially by supplementation with soybean flour without any significant alteration of organoleptic qualities.

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