FOOD RESEARCH INSTITUTE

WORK STUDY ON A CASSAVA PROCESSING DEMONSTRATION UNIT

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A C K N O W L E D G E M E N T

My sincere thanks, first, goes to the Al-ighty God for seeing me through this project in terms of everything.

I am grateful to Mr. W.K. Amoa-Awua, the project manager of the Cassava Processing Demonstration Unit, for his guidance in the writing of this report. I am also grateful to Mr. Ernest Ablorh, the plant supervisor who assisted me during the experimental part of the project.

My gratitude also goes to the staff of the Food Research Institute especially Mr. B.L. Lartey, Chief Research Officer, who helped me in diverse ways during this tudy.

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SUMMARY

The work study at the Cassava Processing Demonstration Unit was carried out on the gari production line under the normal daily operating conditions of the plant. A critical look was taken at the method of peeling and how to monitor it in order to cope with the grating rates of the existing two graters which vary greatly in their capacities. With the sufficient fermentation period of 36hrs a hydraulic press and manual press were compared followed by the disintegration of the dough to enhance easy sieving. The critical moisture content of the dough before roasting which was found to be 44% resulted in achieving the desireable texture. The average particle size of the graded gari was 0.61mm and the packaging rate was 183 sachets of 600g weight per hour. The overall percentage recovery, based on the raw cassava to the finished product, was found out to be 28.00%.

I N T R O D U C T I O N

Cassava is one of the most important and widely consumed root crops in Ghana which can be processed into different products in order to improve upon its storage life.

Cassava cultivars may generally be grouped into the bitter and sweet varieties. The bitter varieties contain more than 50mg of hydrocyanic acids per Kg fresh root whilst the sweet varieties contain less than 50mg of the poisonous compound per Kg of fresh root. Cultivars grown in Ghana are almost invariable of the sweet type.

Due to the nature of the cassava tuber it may be successfully stored permanently by processing into storable forms. Other advantages of placing importance on cassava processing is that it may enhance the introduction of new products and encourage agro-based industries. Some of the most important [redacted] cassava products in Ghana are gari, instant fufu powder, kokonte and cassava dough flour.

Traditional processing of cassava into gari involves peeling and grating of the cassava followed by spontaneous fermentation which occurs during the prolonged dewatering of the grated mash. The fermented pressed dough is then reduced into a granular form sieved and roasted. Roasting gelatinizes and dehydrates the grains. The product is allowed to cool and sieved to remove large lumps and improve upon its appearance.

The drugery and health hazards associated with the traditional method of gari making has led to the study of the various unit operations of gari production by researchers from the Food Research Institute and Industrial Research Institute with the view to upgrading the traditional technology.

The knowledge gain has formed the basis for the establishment of a Cassava Processing Demonstration Unit by the above named institutions of Council for Scientific and Industrial Research (C S I R), in a joint effort with the African Regional Centre for Technology (A R C T) based in Dakar, Senegal. The primary objective of the project is to use the Cassava Processing Demonstration Unit as a training and demonstration unit for training traditional gari makers, policy makers and enterpreneurs improved methods of cassava processing. Even though the unit has the design of an industrial plant in scope of activities, market orientation of product and

plant needs, the significant training component in plant activities limit the plant's commercial objectives and operations.

Work studies are carried out on processing plants to enable personnel in charge assess and improve upon their production efficiencies. It also enables personnel to maximise their operations under standardised working conditions.

This work study was carried out to monitor and assess the various units operations and the general operations of the plant installed at the Demonstration Unit and also to make recommendation as to how to achieve a targeted production daily output of over 400Kg of gari.

This study deals with the material balances and capacities of the various unit operations as well as the nature of the feed and product to and from each unit operation on the processing line.

MATERIALS AND METHODS

With the existing equipment layout and the equipment at the cassava processing plant the work study was carried out under normal operating and working conditions. Gari is produced at the plant through the unit processes as described below.

PEELING

Fresh cassava was weighed and peeled manually. The peeling rate was obtained by determining the time taken to peel 40kg of cassava and the number of personnel involved in peeling. Successive peeling rates were determined and the average peeling rate worked out. Samples of peeled cassava were taken to determine the moisture content.

WASHING

The peeled cassava was then washed in clean water to get rid of any dirt. The washing was done manually with the water being changed periodically.

GRATING

Grating was carried out to reduce the cassava into a wet granular from. Two different graters were used and their capacities compared. These were a Disc Grater and a Drum Grater.

The disc grater consists essentially of a horizontal grating disc fixed to a vertical shaft which is located centrally to the bottom of the outer ring. An inner ring sits above the grating disc with a bar welded across it to serve as a trap for the cassava when fed unto the rotating disc. The grated material passes through an adjustable clearance between the inner ring and the grating disc into a chute for collection. The grater is operated by a 5 horse power (Hp) (3.7KW) electric motor

The drum grater consists of a hopper and a drum driven by a 7.5Hp (5.6KW) induction motor. Peeled Cassava fed into the grater is pushed against the rotating drum to effect grating. The drum is a solid metal with milled rasp teeth and rotates at 700rpm.

48kg of the peeled cassava was weighed and fed into the grater in either case and the time taken to grate the material determined. Samples of grated cassava from each grater were taken and their moisture contents and average particle size determined. The total weight of each grated material as well as its temperature were also determined.

FERMENTATION

Fermentation is necessary for the production of lactic and other organic acids as well as aldehydes and esters all of which give gari its characteristic flavour. Fermentation also enhances the hydrolysis of the poisonous cyanic compound present in the cassava.

The grated cassava were packed in sacks and placed in a fermentation trough and allowed to undergo spontaneous fermentation for 36 hours. Weight before and after fermentation were determined and samples were taken to determine the moisture content. There were no analyses of the organic acids, aldehydes and esters produced.

PRESSING

Pressing is carried out to reduce the moisture level of the fermented cassava dough, making it possible to roast the product.

Two types of presses were used. They are the hydraulic press and manual press.

The hydraulic press has a base on which sits a perforated metallic box with a lid in which the material to be pressed is placed. By cranking the hydraulic bars up and down pressure is exerted on the material via a pressure plate attached to a ram at the upper part of the press. The hydraulic press has a pressure gauge which indicates the operating pressure.

The manual press comprises a metallic box that sits on the base of the press. With the aid of a screw rod, pressure is exerted on the material in the pressure box. There are 3 of these manual presses at the Cassava Processing Demonstration Unit.

37.1kg and 20kg, respectively of the fermented cassava dough were packed in a polypropylene sacks and placed in the metallic box of hydraulic and manual presses and pressed to dewater the material. The time taken to press the material as well as the final weights were determined. The moisture contents before and after pressing were also determined.

DISINTEGRATION

The compactness of the pressed dough is such that it always needs to be disintegrated and sieved before it can be roasted.

The disintegrater is essentially a rotor with spikes on. It is run by a 1.1KW electric motor.

29.6kg of the pressed fermented cassava dough was fed to the disintegrater through a hopper and the time taken to disintegrate the material noted.

SIEVING

Fibrous material in fermented cassava dough is traditionally removed before roasting.

The sieve is a wire mesh mould into a cylindrical shape which is turned manually with the aid of a wheel attached to one of the ends of the siever.

Through a hooper 27.3kg of the fermented cassava dough was fed into the siever and turned. The number of turns and the weight after sieving were determined as well as the time for sieving. The particle size of the sieved fermented cassava dough was also determined.

ROASTING

Roasting is carried out primarily to cook the material. It results in a crispy, palatable and storable ~~and storable~~ product.

Two different types of roasters were used; a traditional roasting pan and 2 large roasting pans rectangular in shape and of the following diamensions 44" X 40.25" X 4.5". Both the traditional and large roasting pans are used on improved stoves with chimneys using firewood as fuel. Smoke produced is removed through the chimneys making roasting more comfortable and less hazardous.

In addition to these the unit has also developed a mechanical roaster. But this was undergoing modification works at the time of the study.

27.7kg of the fermented cassava dough was weighed and poured into the roasting pan. The time taken to roast the material as well as the final weight and moisture content of the product were determined.

GRADING

Gari from the roaster is graded to acquire product of uniform particle size.

The grader comprises a vibrating sieve on which the product is poured and sieved. It is run by a 4.1KW motor.

The gari was weighed and poured onto the mesh for grading. Two graded products of different particle size range were collected. The time for grading was determined as well as the weight and the particle size of the various products.

MILLING

The large lumps from the grader were milled to the required particle size using an attrition mill.

Weight before and after milling were measured as well as the part size.

PACKAGING

The graded gari of the required particle size was then packaged into polyethylene bags.

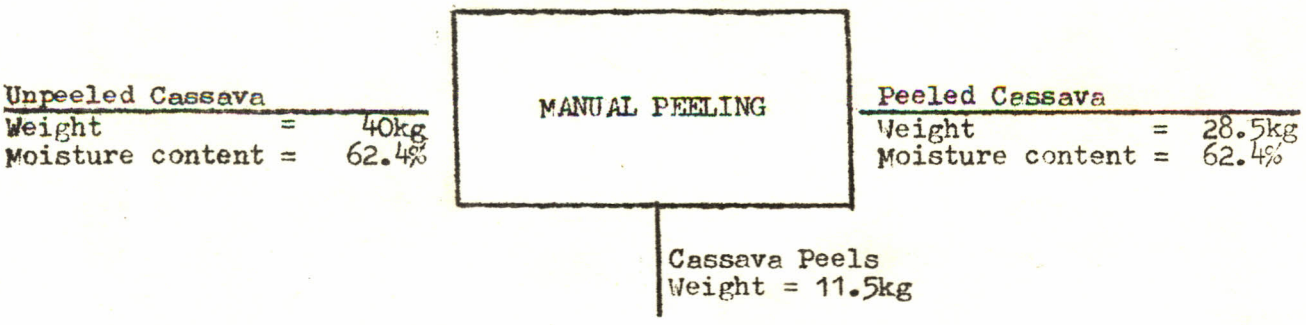
600g of gari was poured manually into each bag and sealed. Time for packaging 197.2kg of gari was determined.

All the experiments were carried out in triplicates.

RESULTS

On each of the units or equipment the experiment was triplicated and the average was determined and used to represent that parameter.

Peeling

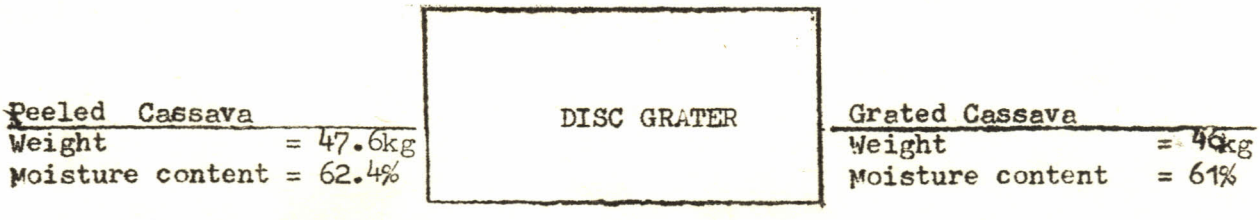


Recovery = 71.25%
Peeling rate = 47kg/Manhr

It took 8 persons 7mins to peel 40kg of Cassava. It yielded 28.5kg of peeled cassava and 11.5kg of cassava peels. The moisture content of the cassava was determined to be 62.4%; and the percentage recovery was 71.25%.

The peeling rate depends on the size of the cassava as well as the period through which the peeling is done. Smaller tubers have got larger surface area per unit volume than bigger tubers of same weight hence the bigger ones have got faster peeling rates than smaller ones. Also by sitting down for long time the peelers become tired and their peeling rate decrease. Percentage recovery also depends on the size of the tubers; peeling small tubers takes more of the cassava alongside with the peels than bigger tubers.

Grating



Motor Power = 3.7KW
Recovery = 96.64%
Grating Capacity 190kg/hr

Peeled Cassava		DRUM GRATER	Grated Cassava	
Weight	= 48.4kg		Weight	= 47.1kg
Moisture content	= 62.4%		Moisture content	= 61.7%

Motor power = 5.6KW
Pwecentage recovery = 97.31%
Grating capacity = 544kg/hr

The disc grater and drum grater took 15 minutes and 6 minutes, respectively, to grate 48kg of peeled cassava; with respective percentage recovery rates of 96.64% and 97.3%. The moisture content of the grated cassava was found to be 61%

The average particle size of the grated cassava using disc grater was 0.78mm in the range of 20mesh to 40mesh (0.84mm to 0.419mm); and that of the drum grater with milled rasp teeth was 0.76mm in the range of 30mesh to 40mesh (0.84mm to 0.419mm). The detailed data on the particle size is presented in appendix 1. In order to get particle size of grated cassava within the required range using the drum grater the cassava had to be grated twice. Despite having to grate the material twice its capacity was nearly three times that of the disc grater. The difference in the grating capacities may be due to the fact that no additional force other than gravity is exerted for the accomplishment of the grating in the disc grater whereas cassava is manually pushed against the rotating abraisvie drum in the drum grater using a pressing block. The differences in weights before and after grating was due to spillage of some of the exudate and the retention of a little grated material in the graters.

Fermentation

Grated Cassava		FERMENTATION TROUGH	Fermented Cassava Dough	
Weight	= 46.0kg		Weight	= 38.5kg
Moisture content	= 61%		Moisture content	= 55.9%

Percentage recovery = 83.7%

46kg of grated cassava was allowed to undergo spontaneous fermentation for 36 hrs. The weight after fermentation was found to be 38.5kg; the decrease in weight was due to removal of exudate during fermentation caused by the weight of the dough. The moisture content of the fermented dough was determined to be 55.9%, and the percentage recovery was 83.7%.

There was decreese in weight of the dough during fermentation due to the loss of some exudate from the grated material. The exudate contains starch and water. During fermentation, the toxicity of the dough was reduced and a characteristic flavour developed. During fermentation, the bacteria, corynebacterium manihot produces lactic and formic acids from starch reducing the pH, thus making it possible for a fungus Geotrichum candida to grow and produce the aldehydes and esters which give the dough a characteristic flavour. The increased acidity also allows an enzyme, linamarase, to hydrolyse the poisonous glucosides int gaseous hydrogen cyanide, which is liberated thus detoxifying the dough. Thus the fermentation period should be enough for these activities to take place.

Pressing

Fermented Cassava dough		HYDRAULIC PRESS	Pressed Fermented Cassava dough	
Weight	= 37.1kg		Weight	= 29.5kg
Moisture	= 55.4%		Moisture content	= 44.0%

Liquor
Weight: 7.6kg

Percentage recovery: 79.6%

Pressing Capacity = 111.3kg/hr

Force = 12tons for 20 mins

Force = 12tons (pressure guage reading) for 20mins =
= 118k N for 20mins

Pressure = 525KN/m^2 for 20mins of 1575KN/m^2 hr.

Temperature rise = 2°C.

Fermented Cassava Dough		MANUAL SCREW TYPE PRESS	Pressed Fermented Cassava Dough	
Weight	=20kg		Weight	=17.9kg
Moisture Content	=54.7%		Moisture content	=48.4%

Liquor
Weight = 2.1kg

Perecentage recovery = 89.5%

Pressing Capacity = 171kg/hr

Temperature rise = 2°C.

Though pressing is carried out to remove enough water from the soggy grated material in order to make it possible to roast, there is a critical moisture level below which the dough cannot be successfully roasted. This is because roasting involves an initial gelatinization which cannot be accomplished in the absence of adequate moisture. The critical moisture level was found to be 44%. The starch to water ratio in the liquor was 1:1. The temperature rose from 28°C in each case but the manual press has got high pressing rate. However, the hydraulic press which requires less human effort to accomplish a batch has got higher overall efficiency than the manual press. The average time for pressing a batch of 20kg using the manual press was found out to be 7mins with an average time for loading and unloading the press of 2 mins. Hence the operational pressing time was found out to be 171kg per 80 mins. Similarly, an average time of 2 mins was used for the hydraulic press. Therefore, the operational pressing time was found out to be 111.3kg per 70 mins.

Disintegration

Pressed Fermented Cassava Dough			Disintegrated Fermented Cassava Dough
Weight	= 29.60kgs	DISINTEGRATER	Weight =29.20kg
Moisture Content	= 44.2%		Moisture Content =44%

Percentage recovery = 98.65%

Disintegration Capacity = 208kg/hr

The disintegrater took 9 mins to disintegrate 29.6kg of pressed fermented cassava dough at percentage recovery of 98.65% The moisture content of the dough was determined to be 44%.

There was about 1.35% accumulation of the dough fed into the unit with a slight decreasein moisture content and negligible rise in temperature.

Sieving

Disintegrated Fermented Cassava Dough			Sieved Fermented Cassava Dough
Weight	= 27.3kg	MANUAL ROTARY SIEVE	Weight = 26kg
Moisture content	= 44%		Moisture content = 44.00%

Percentage recovery = 95.24%

Sieving Capacity = 394.65kg/hr

It took the manual rotary sieve 4mins to sieve 27.3kg of fermented cassava dough. The moisture content was found to be 44% and percentage recovery of 95.24%

The average particle size of the sieved fermented cassava dough using the manual rotary sieve was 0.58mm in a range of 20 mesh to 40 mesh (0.84mm to 0.419mm). The average weight of chaff sieved out of the dough was 1.3kg or an average of 5kg per 100kg of disintegrated fermented cassava dough.

Manual Roasting

Sieved Fermented Cassava Dough			Gari	
Weight	=27.7kg	LARGE RECTANGULAR ROASTING PAN	Weight	= 15.9kg
Moisture Content	=44.0%		Moisture Content	= 4.8%

Percentage recovery = 57.4%

Roasting Capacity = 31.34kg/hr

Sieved Fermented Cassava Dough			Gari	
Weight	= 8.5kg	TRADITIONAL ROASTING PAN	Weight	= 4.7kg
Moisture Content	= 48.4%		Moisture Content	= 5.5%

Percentage recovery = 55.3%

Roasting Capacity = 11.2kg/hr

Roasting occurs in two stages; gelatinization and dehydration. Gelatinization results in the dough being cooked and cannot be accomplished if the product is overstirred as for example may happen in a mechanical roaster. Here the moisture content of the fermented cassava dough has got a role to play in the cooking. This is because the gelatinization needs a minimum level of moisture content of the feed for it to be accomplished. This critical moisture level was found to be 44% in the experiment. Should the level fall below this critical value the product would be powdery. The optimum roasting temperature was found to be 115°C. The above stated weight of the dough fed to the large rectangular roasting pan was fed in 3 batches with an average roasting time of 18mins per batch. Similarly with an average roasting time of 15mins per batch the dough fed to the traditional roasting pan was in 3 batches. In both cases the average particle size of the gari was 0.61mm within a range of 20mesh to 40mesh (0.84mm to 0.419mm).

Grading

Ungraded Gari		GRADER	Graded Gari	
Weight	= 15.9kg		Weight	= 15.9kg
Moisture content	= 4.8%		Moisture content	= 4.8%

Percentage recovery = 100%

Grading Capacity = 238kg/hr

15.9kg of ungraded gari fed to the grader was graded to two fraction: the acceptable particle size and the large lumps fractions, for 4mins. The former was collected as the underflow and the latter as the overflow.

The underflow of the grader recorded 12.7kg or 80% of the total graded gari with an average particle size of 0.61mm in a range of 20mesh to 40 mesh (0.84mm to 0.419mm). The overflow was 3.2kg or 20% of the total graded gari with an average particle size of 1.29mm in a range of 10 mesh to 20 mesh (2mm to 0.84mm)

Milling

Gari (large lumps)		DISC ATTRITION MILL	Gari (Small granules)	
Weight	= 31.7kg		Weight	= 31.1kg
Moisture content	= 4.8%		Moisture content	= 4.7%

Percentage recovery = 98.11%

Milling capacity = 380.4kg/hr

31.7kg of the large lumps of the graded gari was milled for 5 mins with a percentage recovery of 98.11%.

The average particle size of the milled gari was 0.58mm. There was a loss of 0.6kg as accumulation and powder.

Packaging

Gari		BAGGING, WEIGHING AND SEALING	Gari	
Weight	= 197.2kg		Weight	=197.2kg
Moisture content	= 4.7%		Moisture content	= 4.7%

Percentage recovery = 100% on total

Packaging rate = 119.5kg/hr

Number of Personnel = 8

8 persons took 1 hr 40mins to bag, weigh and seal 197.2kg of graded gari in sachets.

The gari was packaged at 600g (0.6kg) per sachet manually. 303 instead of an expected 328.67 sachets were obtained. Since the product is sold in sachets, there was a financial loss of 7.8% resulting from packaging.

It was noticed that some of the sachets weighed more than 600g whilst a few weighed less which resulted from human error in weighing which is a major contributing factor. The packaging rate with respect to the number of sachets was 183 sachets per hour. Hence the percentage recovery of 100% and packaging rate of 119.5kg/hr is with respect to the gari handling. Thus there is no actual loss of the product during packaging except that the number of sachets expected was not obtained due to overweighing.

DISCUSSION

The existing equipment layout of the gari production line at the processing hall and roasting section of the Cassava Processing Demonstration Unit is as shown in fig. 1. A wet processing section proceeds a dry processing section. There is adequate working area around each equipment with regards to the number of workers per machine and the flow of materials or product through each unit.

The percentage recovery rate of gari from the fresh cassava was found to be 28%. The recovery rate is however affected by the age of the cassava. Less mature cassava has a higher moisture level hence the recovery rate is low. Over aged cassava is woody and would have a low recovery rate since most of the fibrous material will be rejected during processing. The purchasing staff at the plant would therefore have to be selective in their procurement of cassava in order to have good yield. The recorded yield or percentage recovery of 28% represented fairly well matured cassava; thus the average recovery rate over a one year period is about 25%.

The flow of material through the existing plant at the Cassava Processing Demonstration Unit is not satisfactory since discripancies exist between the installed capacities of the various unit operations and processes. Fig. 2 shows that the various capacities are not synchronised hence a build up of material occurs at some stages of processing if the graters are operated at full capacity. Assuming the total grating capacity of 735kg/hr. as an acceptable standard for a batch operation, one would expect a peeling rate of 1030.2kg/hr but the recorded rate was only 376kg/hr. This low peeling rate does not, however, pose a major obstacle since it can merely be increased by engaging more hands to do the peeling.

The grated product is next fermented and pressed. The capacity of the plant for fermentation is somewhat unlimited since it is carried out spontaneously by merely packing the grated material into polypropylene bags and allowing it to stand for 36hrs. The pressing capacity of 624.3 kg/hr. instead of 597.8kg/hr is however even higher than required to allow the free flow of material along the production line. The capacities of the equipment for the subsequent operations of disintegration and sieving, 208.3 and 394.65kg/hr. respectively, instead of an expected 535.1 and 527.9kg/hr show that materials would build up during these

Fig 1 EQUIPMENT LAYOUT OF THE CASSAVA PROCESSING DEMONSTRATION UNIT

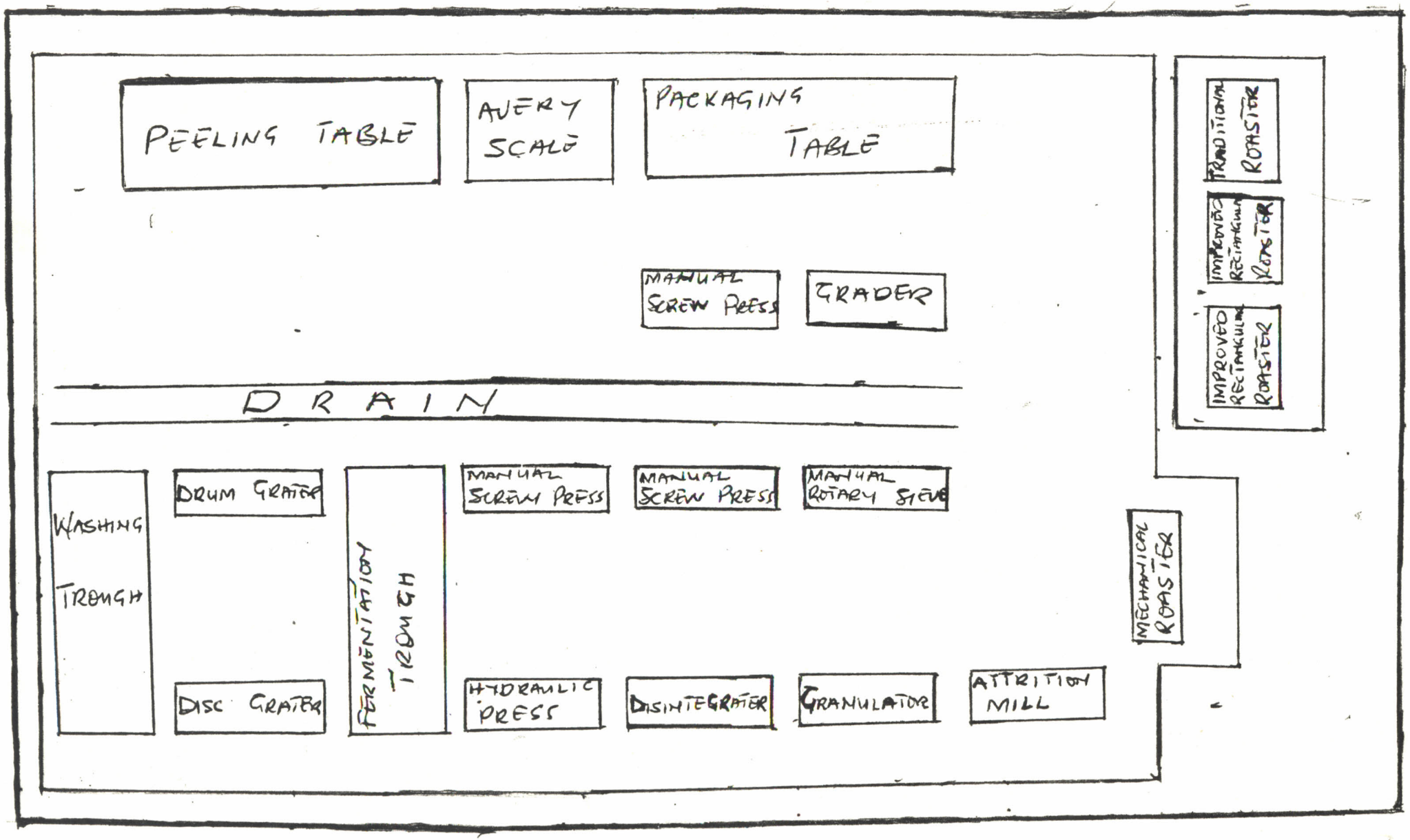
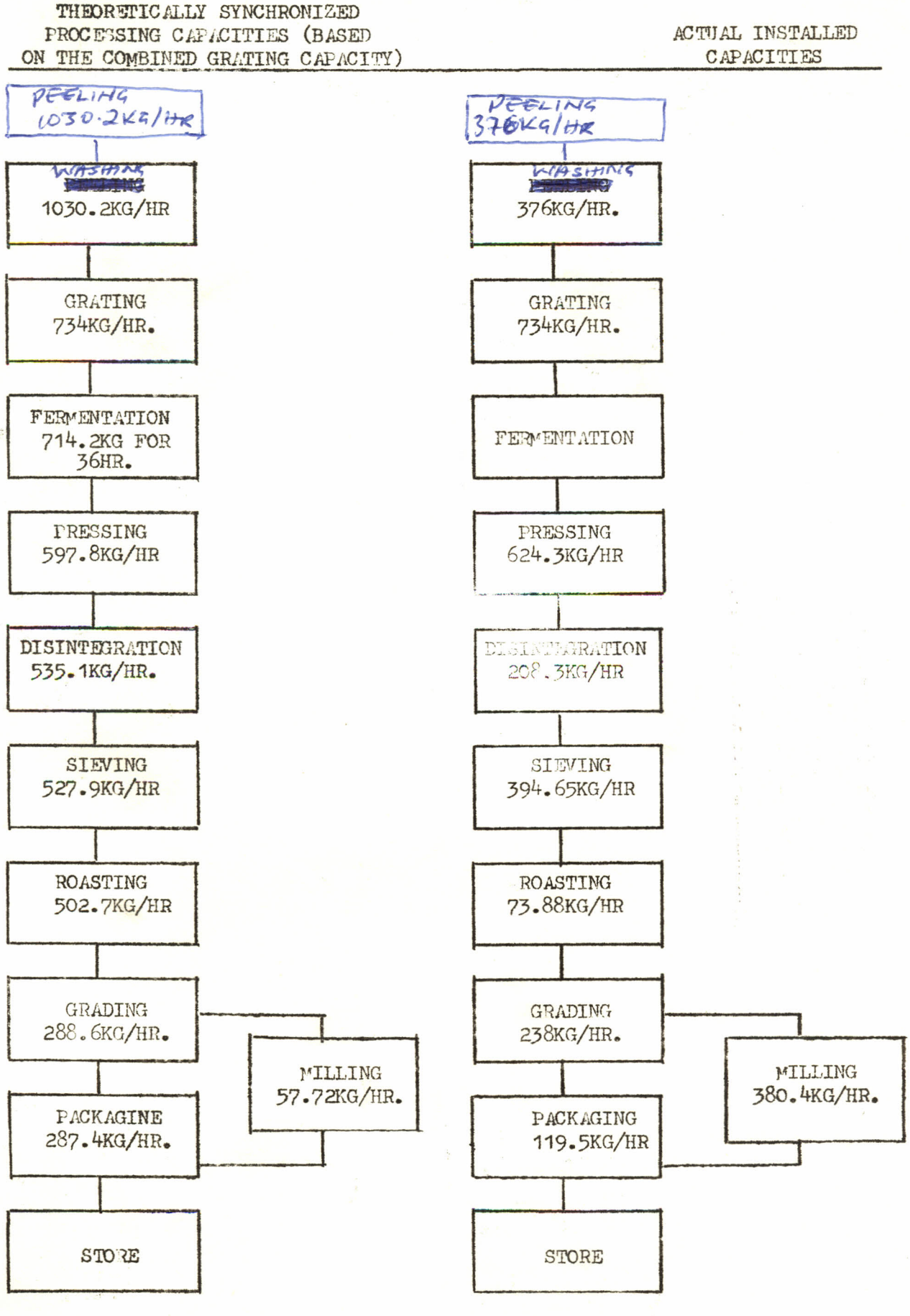


FIG. 2 COMPARISION OF ACTUAL INSTALLED CAPACITIES WITH THEORETICALLY SYNCHRONIZED PROCESSING CAPACITIES



operations should be graters be operated at their full capacities. Similarly, fig 2 shows that the capacities for the final operations of roasting, grading and packagin, 73.88, 238 and 119.5kg/hr, respectively, fall short of the expected rates of 502.7, 288.6 and 287.4kg/hr which would ensure a smooth flow of material through the plant. It is only the milling capacity of 380.4k /hr, a secondary operation, which far exceeds the expected capacity of 57.2kg/hr and is able to cope with the capacities of the graters.

It is obvious from the above discussions that the peeling, disintergration, sieving, roasting, grading and packaging capacities have to be increased for the smooth operation of the plant exploiting the capacities of the graters. However, packaging rate as in the case of peeling can simply be increased by engaging more hands whereas additional equipment would be needed for the other operations.

Since no actual build ups of materials were observed during the study except in the case of roasting, it would seem that under normal daily operations the graters are rather underutilized by operating them for short periods in order to co-ordinate their output with the capacities of the other equipment.

The project document for establishing the Cassava Processing Demonstration Unit targetted a daily processing capacity of 2 tons (2,000kg) of cassava. Models for achieving this level of production are produced in tables 1 and 2. To process 2 tons of cassava a day using the existing facilities at the Cassava Processing Demonstration Unit, a model has been drawn up in table 1 taking into consideration the number of personnel and the length of time needed to carry out each operation. A comparison of a model and the installed capacities in table 2 shows that this scale of operation can be achieved only if additional roasters are installed to raise the roasting capacity from 73.88kg/hr to 122/hr. All the other unit operations are capable of handling that quantity of material.

Even though the target of processing 2 tons of cassava daily can easily be achieved by installing additional roasters, it would be advantageous to raise the processing capacity even beyong this since the installed capacities of all the other unit operations are in excess of this requirement. It is suggested that all capacities are raised to cope with the grating capacity of 734kg/hr. This will raise the capacity of the plant to handle over 8 tons of cassava daily and make operations much more economically rewarding. To handle this volume of material there will be a need to install six more improved stoves however emphasis should be placed on mechanical rather than manual roasting since the latter will necessitate the employment of additional staff. Modification work on the Mechanical roaster should therefore be speeded up and when found satisfactory additional models fabricated.

TABLE 1 A MODEL FOR PROCESSING A DAILY BATCH OF 2,000KG OF FRESH CASSAVA USING THE EXISTING PLANT AT THE CASSAVA PROCESSING DEMONSTRATION UNIT

UNIT OPERATION	PERCENTAGE RECOVERY	PERCENTAGE RECOVERY WITH RESPECT TO RAW MATERIAL	INSTALLED CAPACITY (KG/HR).	OUTPUT (KG)	PERIOD OF OPERATION (HRS)	NUMBER OF PERSONS TO CARRY OUT OPERATION
Cassava	-	-	-	2,000	-	-
Peeling	71.25	71.25	376	1,425	5.32	8
Grating (C) 1. Disc grater 2. Drum grater	97.31	69.33	734	1,386.6	1.94	2
Fermentation	83.70	58.03	-	1,160.6	36	-
Pressing (C) 1. Hydraulic 2. Manual (3)	89.50	51.94	624.3	1,038.8	1.86	2 2
Disintegration	98.65	51.24	208.3	1,024.8	4.99	2
Sieving	95.24	48.80	394.65	976	2.60	2
Roasting (C) 1. large pan(2) 2. traditional pan	57.40	28.01	73.88	560.2	13.21	3
Grading	100.00	28.01	238	560.2	2.35	2
Milling	98.11	27.90	380.4	(109.9)	(0.29)	2
Packinging	100.00	27.90	119.5	558	4.67	8

(C) = Combined

The Percentage recovery against the milling in the table resulted from the calculation basing on the fact that 20% of the total graded gari was milled at a recovery of 98.11%, and its corresponding value are calculated accordingly.

TABLE 2 A MODEL FOR PROCESSING A DAILY BATCH OF 2,000KG FOR 8HRS

UNIT OPERATIONS	OUTPUT (KG)	REQUIRED CAPACITIES (KG/HR)	EXISTING CAPACITIES (KG/HR)
Cassava	2,000	-	-
Peeling	1,425	250	376
Grating	1,386.6	178.13	734
Fermentation	1,160.6	-	-
Pressing	1,038.8	145.08	624.3
Disintegration	1,024.8	129.85	208.3
Sieving	976	128.10	394.65
Roasting	560.2	122	73.88
Grading	560.2	70.03	238.
Milling	(109.9)	(14.01)	380.4
Packaging	558	69.75	119.5

NB. Only 20% average of the graded gari was milled hence the values in the brackets are for the milling by pass.

CONCLUSION

By installing two more improved stoves, the plant at the Cassava Processing Demonstration Unit would be able to process 2 tons of Cassava daily as stipulated by the project document for establishing the unit. At the moment he plant can process an average of 1.2 tons of cassava per day. The plant, however, has a potential for processing over 8 tons per day. The layout of the plant is good and the working space provided around each machine is adequate.

The yield of gari from cassava at the time of study was 28% but this is dependent on certain factors including the variety of cassava and its age. The critical moisture content for the successful roasting of fermented cassava dough into gari was found to be 44%.

The capacities of the various unit operations are not synchronised hence materials are not able to flow smoothly through the plant if each machine is operated at its full capacity. During operations, some machines have to be underutilized before other machines are able to cope with their outputs. Despite this a build up of materials occur during roasting. These discrepancies in the capacities of the various unit operation have to be ratified before the plant can be operated satisfactorily.

RECOMMENDATION

This work study has made it clear how to eliminate some of the bottlenecks in the gari production line in order to moniter the production rate.

Thus since there has not yet been any mechanised means of peeling about 8 more persons could be employed to increase the overall peeling rate in order to get the feeding requirement to the graters (ie especially the drum grater) to avoid the under utiliazation of the equipment.

A more powerful electric motor could be installed to replace the existing electric motor in the disintegrater, or a bigger model has to be acquired, to increase its throughput in order to cope with the higher sieving capacity of the siever.

Concerning roasting there is no other alternative than to install 2 more of the improved traditional rectangular roaster to contain the rate at which the fermented cassava dough was sieved in order to increase the production rate.

The packaging staff should be more careful and their work closely supervised to avoid over-weighing.

The existing equipment layout, with respect to the flow sheet of gari production could be maintained. However, the roasting section could be relocated for easier access to it in order to economise time during transfer of feed (fermented cassava dough) to the roaster:

The above recommendations if implemented would help in the efficient running of the plant.

APPENDIX 1

PARTICLES SIZE ANALYSES (USING ASTM SCREENS)

Disc Grater

Screen Opening Diameter (mm)			Weight of Sample on Screen (g)	Weight Percentage (%)	Product of Screen Opening Diameter and Weight Percentage
2.00	(10	mesh)	8.7	8.7	0.174
0.84	(20	")	54.9	54.9	0.461
0.419	(40	")	27.5	27.5	0.115
0.297	(50	")	7.9	7.9	0.023
0.178	(80	")	1.0	1.0	0.002
0.104	(140	")	-	-	-
0.0533	(270	")	-	-	-
Pan			-	-	-

Total = 0.775

∴ Average particle size of grated cassava = 0.78mm

Drum Grater

Screen Opening Diameter (mm)			Weight of Sample on Screen (g)	Weight Percentage (%)	Product of Screen Opening Diameter and Weight Percentage (mm)
2.00	(10	mesh)	11.90	11.89	0.2378
0.84	(20	")	40.30	40.26	0.3382
0.419	(40	")	35.60	35.56	0.1490
0.297	(50	")	10.60	10.59	0.0315
0.178	(80	")	1.60	11.60	0.0028
0.104	(140	")	0.10	0.10	0.0001
0.0533	(270	")	-	-	-
Pan			-	-	-

Total = 0.759

∴ Average particle size of grated cassava = 0.76mm

Siever

Screen Opening Diameter (mm)	Weight of Sample on Screen (g)	Weight Percentage (%)	Product of Screen Opening Diameter and Weight Percentage (mm)
2.00 (10 mesh)	0.6	0.6	0.0120
0.84 (20 ")	40.00	39.96	0.3357
0.419 (40 ")	45.3	45.25	0.1896
0.297 (50 ")	12.2	12.19	0.0362
0.178 (80 ")	1.7	1.70	0.0030
0.104 (140 ")	0.3	0.30	0.0003
0.0533 (270 ")	-	-	-
Pan	-	-	-

Total = 0.577

∴ Average particle size of sieved cassava dough = 0.58mm

Roaster

Screen Opening Diameter (mm)	Weight of Sample on Screen (g)	Weight Percentage (%)	Product of Screen Opening Diameter and Weight Percentage (mm)
2.00 (10 mesh)	2.9	2.90	0.0580
0.84 (20 ")	41.0	40.96	0.3441
0.419 (40 ")	39.4	39.36	0.1649
0.297 (50 ")	10.3	10.29	0.0306
0.178 (80 ")	4.5	4.50	0.0080
0.104 (140 ")	1.6	1.60	0.0017
0.0533 (270 ")	0.4	0.40	0.0002
Pan	-	-	-

Total = 0.6075

∴ Average particle size of gari = 0.61mm

Grader Underflow

Screen Opening Diameter (mm)		Weight of Sample on Screen (g)	Weight Percentage (%)	Product of Screen Opening Diameter and Weight Percentage (mm)
2.00	(10 mesh)	0.3	0.3	0.0060
0.84	(20 ")	49.6	49.6	0.4166
0.419	(40 ")	39.5	39.5	0.1655
0.297	(50 ")	7.2	7.2	0.0214
0.178	(80 ")	2.5	2.5	0.0045
0.104	(140 ")	0.7	0.7	0.0007
0.0533	(270 ")	0.2	0.2	0.0001
Pan		-	-	-

Total = 0.6148

∴ Average particle size of gari = 0.61mm

Grader Upperflow

Screen Opening Diameter (mm)		Weight of Sample On Screen (g)	Weight Percentage (%)	Product of Screen Opening Diameter and Weight Percentage (mm)
5.66	(3.5 mesh)	1.7	1.69	0.0957
2.00	(10 ")	32.6	32.50	0.6500
0.84	(20 ")	64.3	64.11	0.5385
0.419	(40 ")	0.7	0.70	0.0029
0.297	(50 ")	0.2	0.20	0.0006
0.178	(80 ")	0.3	0.30	0.0005
0.104	(140 ")	0.3	0 30	0.0003
0.0533	(270 ")	0.2	0 20	0.0001
Pan		-	-	-

Total = 1.2886

∴ Average particle size of gari = 1.29mm

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