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Microprocessor Based Automation Of Cassava Processing For Increased Production Of Organic Food And Bio Fertilizer.

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Abstract:
Micro processor based automated cassava processing system was developed to mimic the human activities in processing cassava into garri. The automated system was attached with a bio-fertilizer processing reactor. 25 kg of garri was produced using the automated system and the common man-mechanical system that is currently and predominantly used to process garri. The time taken and the quantity of waste generated by the two systems are tabulated in table 1 and 2 respectively. 50kg of cassava was lost as waste in the process of producing 25kg of garri. The automated system achieved 88.99% gain in human active hour involvement in cassava processing against the man-mechanical system. The waste of 50kg of cassava for every 25kg of garri processed was recovered. This research proved that Nigeria as the largest producer of cassava can harvest and utilize cassava bio-fertilizer that is 19 times on yearly bases more than the highest inorganic fertilizer consumption of the country for the past ten years on yearly bases.

Keywords: *Automation, man-mechanic, micro processor, bio-fertilizer, organic food, cassava, garri.*

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I. Introduction:

Every living thing needs nourishment for growth and better development. Animals eat plants and flesh. Plants take in fertilizers, both chemical and organic fertilizer. Cassava is a plant whose leaves are used as vegetable and the roots develop into tubers. The stem of cassava plant is used for its propagation while the cassava tubers are processed into different food items. 80% of the Nigerian household take at least one of the food products from cassava on daily bases. Nigeria produces about 59 million tons of cassava making her the largest producer in the world [1].

Nigeria currently has an estimated population of 200 million. Out of this population, 48.04% (99 million) percent are rural farmers that cultivate and process this quantity of cassava in dispersed settlements [2]. They use continues cultivation method which deplete the soil nutrients. To restore the soil nutrient and increase production some of the farmers use chemical fertilizers.

The population of the country is growing and it is estimated to be about 400 million by 2050[3]. This population must be sustained food wise. In addition to the population increase, industries that process cassava into non food items like glue are springing up in Nigeria; this number of such industries is expected to increase by 2050. These population and industrial increase, is placing high demand for cassava production.

Nigeria as a country is faced with:

1. A steady growing population.
2. The method of farming that produces cassava is subsistent.
3. Desertification, Erosion and Flooding is claiming some part of the land used for cassava cultivation.
4. Most of the rural farmers can't afford to purchase the needed chemical fertilizer to boost the cassava production.

All these militate against the production of sufficient cassava to satisfy the demand.

In all the items that cassava can be processed into, garri is for now the food item processed from cassava that is placing the biggest demand on cassava in Nigeria. To get I kg of garri about 2kg of cassava is lost as waste [4]. This paper uses the micro processor based automation of cassava processing system into garri as a system that

will produce garri and recover the 2/3 cassava that would have been lost as waste as a renewable organic fertilizer for the cultivation of cassava in Nigeria and other African countries.

II. Review of the related literature.

Cassava is a drought resistant and high yielding crop. It takes about an average of 9 months for it to mature depending on the type. The matured roots can be stored underground up to three years. It can be cultivated in any part of the country. It is the major source of carbohydrate like rice, maize, yam etc[5]. the global production of cassava as at 2018 was 277 million tones. Africa contributed 62% of this with Nigeria as the highest producer contributing 21%. The percentage contribution of the 5 countries that produce the largest quantity of cassava is as follows: Nigeria 21%, Thailand 11%. DR Congo 11%, Ghana 8%, Brazil 6% and others 43%[6].

Cassava grows well in all soil, especially in a non long time water logged soil. They can produce leaves, stems, tubers (roots) and flowers for the variety that produces flower in even a low nutrient soil. They do far much better in a soil with good nutrient as their growth response to nutrient presence is directly proportional. Cassava as a plant can be processed into the following food products: Garri, kisanvu, kwem, cassava paste, dried cassava chips, cassava flour, cassava starch, fermented and baked semolina, cassava pasta, cassava bread, livestock feeds, ethanol, detrox, caramel etc. these products are done both traditionally and industrially. They are produced from both the roots and the leaves of cassava plant both for human, animal and industrial use.[7][8][9][10][11]

The apparent consumption of fertilizer in tons in Nigeria from 2015 to 2019 is as follows 617,897; 959,364; 1,564,816; 1,475,950; 861,609 respectively. The year 2017 recorded the highest fertilizer consumption to the tone of 1.5 million tons. They were a rise in consumption from 2015 to 2017 and decrees from 2017 to 2019. This may be attributed to availability, cost, policy, apathy etc. the consumption rate stated above is not for a particular inorganic fertilizer but for all types of inorganic fertilizer produced or imported into the country[12][13]. Government has employed many ways of making inorganic fertilizer available and affordable to the farmers. The government target has always been the rural and the small scale holder farmers who collectively produce the greater percentage of the agricultural products consumed in Nigeria. Some of the measures employed by the government include fertilizer subsidy, establishment of fertilizer producing plants in Nigeria, grass root fertilizer distribution to farmers etc[14][15][16].

All varieties of cassava grow better in an environment where the soil nutrient is much. A review of research works done in Nigeria, Ethiopia, Thailand and Brazil pointed out to the same fact that the growth performances of the cassava crop in response to fertilizer application is very significant, independent of the species of cassava[18][19]. There was a better growth in terms of size of tuber, starch content of the tuber, number of leaves and the size and height of the stem. Both organic and inorganic fertilizer had a very significant positive growth effect. A blend of the two in an appropriate ratio is still better. Nevertheless organic and inorganic fertilizers had their strength and weakness in the farmers' preferences [20][21].

Generally farmers prefer organic fertilizers because of its long term positive effect in the soil. It encourages the activities of farmers' friendly organisms, insects and worms in the soil. It has a more convenience of application that is, no special strict rule of application. The inorganic fertilizer is more commonly available and has a more focus of most government on its distribution.[22][23].

Common food products from cassava in Nigeria are named with their corresponding percentages as follows: Garri 74%, Flour 14%, Starch 6%, Ethanol 3% and others 3%[24]. From this statistics, garri is the food cassava is most processed into. Garri is also the biggest source of carbohydrate in Nigeria. The process of processing cassava into garri includes: root harvesting, peeling, washing, grating, dewatering or pressing, fermentation, cake breaking, sieving, toasting and packaging. These process activities have been mechanized. Some parts have been automated. All the mechanization and automation is to reduce the human labour input in processing cassava into garri[25].

The process of processing cassava into garri has been mechanized. Attempts have been on going on how to automate the process. The individual stages of processing cassava into garri have been mechanized with a record of high human input in all the stages. To eliminate these human inputs, there have been several attempts to automate the activities of cassava processing into garri. The automated stages come with sensitive challenges. In the human-mechanical system, the cassava lose in garri processing is 2/3kg, only 1/3kg of the initial weight of the cassava is converted into garri. Most of the automated machines cause more waste and they don't have the type of human peeling efficiency yet[26][27][28][29].

III. Summary Of Reviewed Literature:

Nigeria is the highest producer of cassava to the tone of about 59 million tons per annum. 74% of this cassava is processed into garri. The Processes of processing cassava into garri generates a loss of 2/3kg of the cassava by mass. The man-mechanical system of processing cassava into garri remains the most efficient in peeling and with the 2/3kg loss. Other automated machines in processing cassava into garri has recorded more

waste. The fertilizer consumption of Nigeria from 2015 to 2019 was highest in 2017 to the tone of 1.5 million tons. Cassava responds positively to all fertilizers both organic and inorganic, though a blend gives a better result.

IV. METHODS AND MATERIALS:

The quantity of waste in bio fertilizer and time in the current system of processing cassava into garri.

The processing of cassava into garri starts with the harvesting of the roots. Harvesting takes place in the farm. Some farmers will take the harvested roots home before peeling off the bark with knife while others peel in the farm. The peeled roots are washed. The washing can take place at home before the roots are taken to a grating center where the roots will be grated into paste.

Packets of small community settlements have a grating center. This center will also come with a dewatering machine. Grating, dewatering and fermentation take place in the center. After about 24 hours the farmer comes back to take the cassava cake home. At home the cake is broken, sieved and toasted into garri.

Every stage of garri processing comes with some waste. At peeling stage, the peeled off bark and some part of the starchy flesh is lost. When washing the roots some quantity of starch soluble in the water is lost. At grating some quantity of cassava are lost to the grating machine. At the pressing and dewatering section both water and starch content of the roots are lost. At cake breaking and sieving, non-properly grated particles of the root are lost. At toasting, light cassava particles and water are lost. Figure 1 below shows the flowchart diagram of the process stages of cassava to garri and their corresponding waste stages.

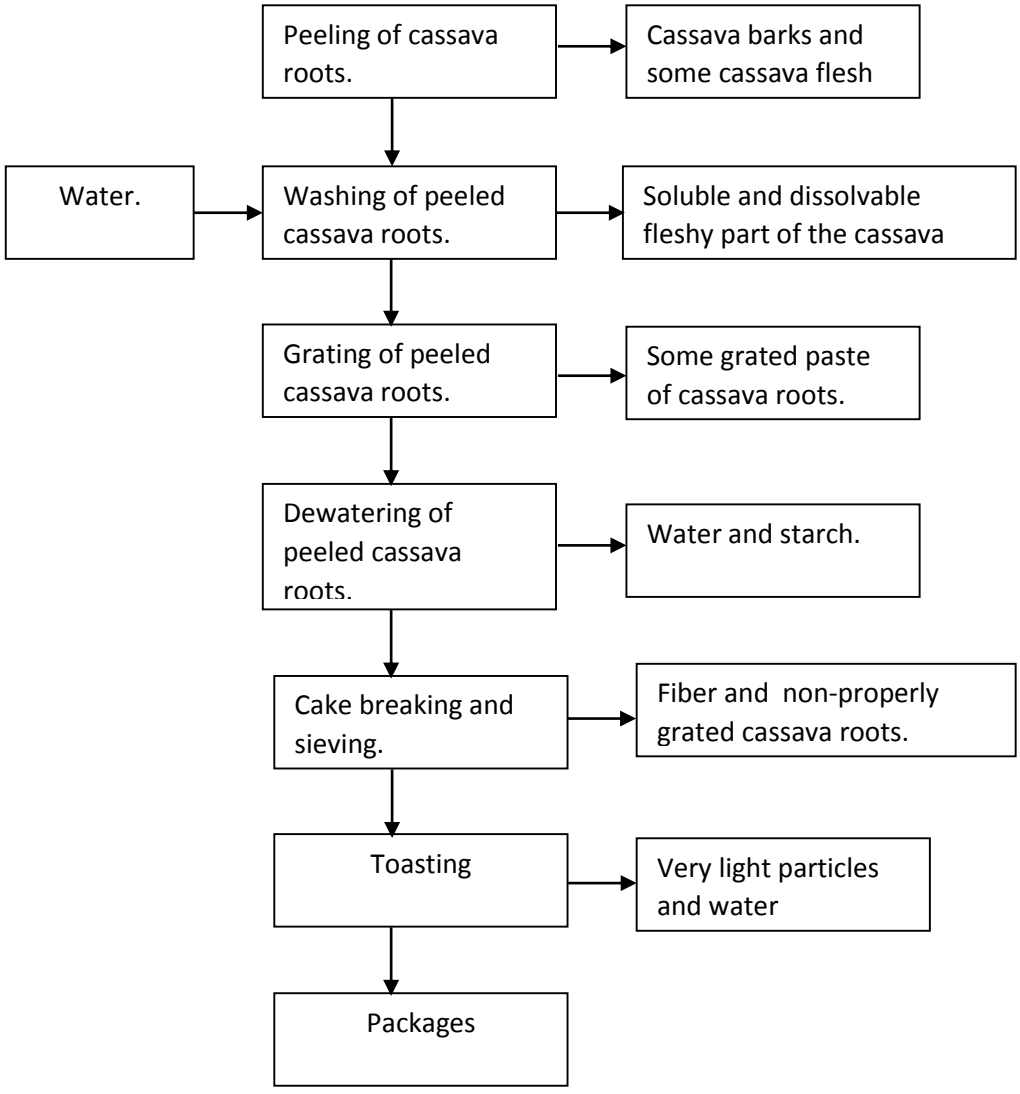

Figure 1: flow chart diagram of the process stages in cassava processing and the corresponding wastes.

From the above scenario cassava loses take place at the farms, at the rural homes and at the processing centers. The reason for this dispersed losses is because farmers have not adopted a cassava processing system that will take off man in the system and carry out all the cassava processing activities in one place. The micro processor based automated cassava processing system will collect all the wastes automatically and almost remove man from the processing of cassava into garri.

75kg of cassava was harvested and processed into 25 kg of garri by a farmer. All the process activities and the time taken for each activity was recorded and tabulated as shown in table 1 below.

The quantity of waste in bio fertilizer and time using Microprocessor based Automation of cassava processing into Garri (MPB-ACPG):

Micro processor based automation of cassava processing system was developed to mimic all the human activities in processing cassava into garri. The peeling of cassava is done by intelligent robot arms. The arm picks the cassava root and peels off the bark on the peeling blade. The peels are automatically collected using a collecting pan and transferred to the waste collection point.

The peeled cassava is dropped into a washing chamber where water is pumped in, and the cassava is washed. The water used in washing the cassava is automatically drained to the waste collection point.

The washed roots are loaded into the grating chambers. The roots are grated into paste. The paste is dewatered and fermented in a dewatering chamber. The water and soluble starch that comes out as waste here are automatically collected to the waste collection point.

After dewatering and fermentation, a cake is formed. This cake is conveyed to the cake broking chamber, where cake breaking and sieving takes place. Large particles that could not break and the fibers that were not grated are automatically collected to the waste collection point.

All the wastes of this process are collected into the bio-digester for anaerobic digestion for the production of bio-fertilizer. Figure 2 below is the schematic diagram of the machine described above.

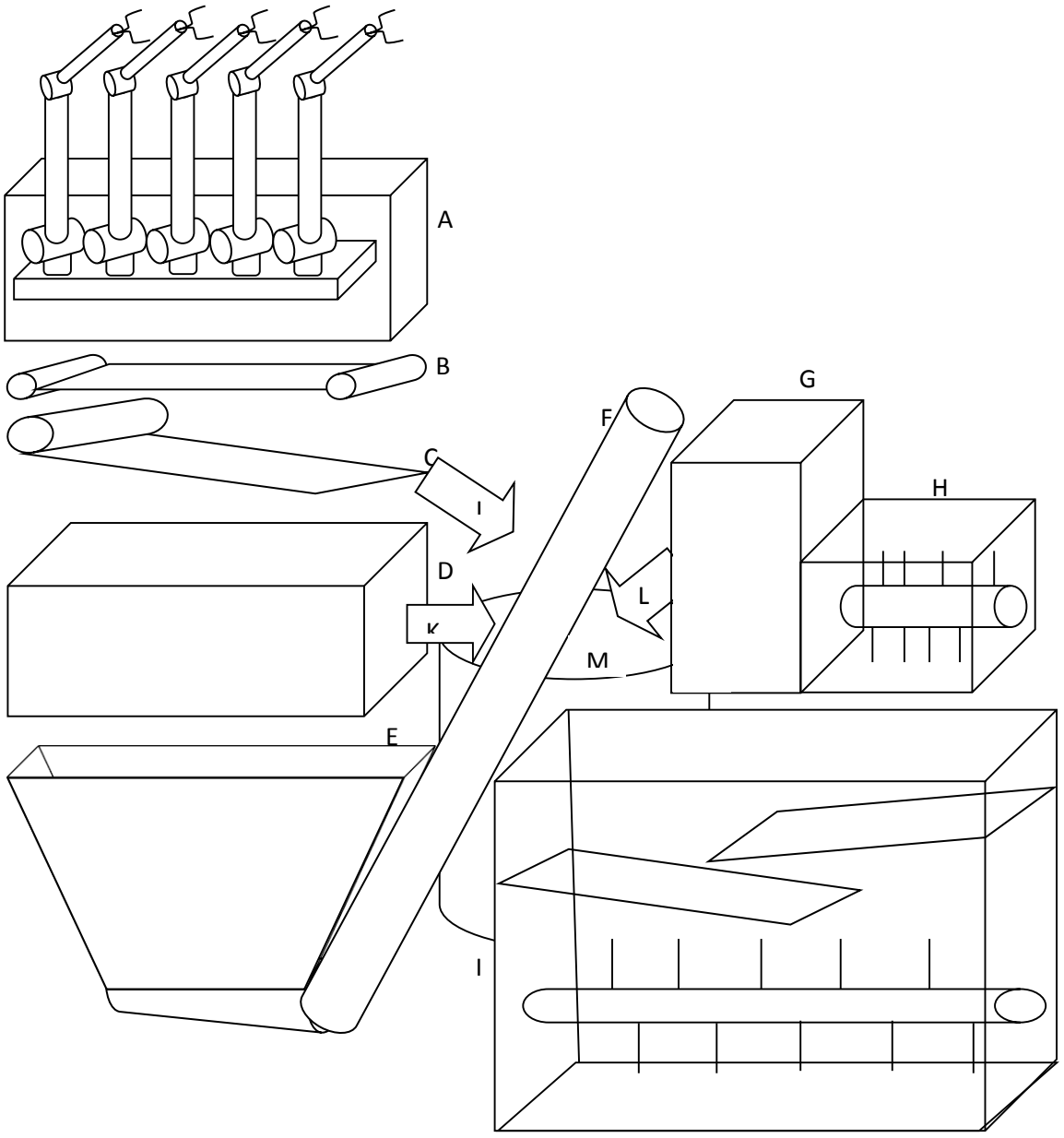

Figure 2. The Schematic Diagram of the Micro controller based Automated cassava processing system

The schematic diagram above show sections numbered A to M.
A is the chamber where cassava is loaded. It is also attached with 5 intelligent robot arms. B is the peeling blade, C it the peeled bark collection pan. It drops the peels into the bio-reactor M, through the channel mark J. D is the washing chamber. The dirty water is drained to the bio-reactor through K. E is the grating chamber. The grated paste is transferred to the dewatering, pressing and fermentation chamber G, through the pipe F. the cake from chamber G is broken and sieved in chamber H. the wastes of chamber G and H are transferred to the bio-reactor through L. toasting and packaging takes place in chamber I. chamber M is the bio-fertilizer reactor where the production of organic fertilizer takes place.

75 kg of cassava was harvested to be processed into 25kg of garri using Micro processor based Automated cassava processing system. The time for each activities of the machine was taken and the result is as presented in table 2 below.

V. Result:

Table 1 and 2 below is the representation of time taken by all the activities of processing cassava into garri using a man-mechanical means and using the developed micro controller based automated cassava processing system respectively.

Table 1: total time and man net time in hours to mechanically process 25kg of garri from 75kg of cassava.

S/N	processing activity to produce 25kg of Garri from 75kg of cassava	Average time(hrs)	Comments
1	Root uprooting (Harvesting)	1	This Depends on the soil type, nature of roots and human strength.
2	Transportation. (15.2 km)	0.333	20 minutes, depending on nature of road, transportation means and distance of farm to the home of the farmer.
3	Cassava bark Peeling	2.5	This depends of the size and nature of the root, how fast the human being can peel and sharpness of the knife.
4	Washing of peeled cassava	0.5	It takes 30 minutes, depending on the washing method.
5	Transporting peeled roots to and back from the grating site(30km)	0.666	40 minutes depending on nature of road, transportation means and distance of farm to the home of the grating center.
6	Grating of cassava roots	0.5	30 minutes Depending on the grating wheel sharpness.
7	Bagging of grated roots	0.083	Average of 5 minutes
	Pressing of bagged pastes	0.5	Average of 30 minutes
8	Fermentation of dewatered paste	24	To reduce the quantity of cynic acid.
9	Transportation fro grating site back to the house	0.666	40 minutes depending on nature of road, transportation means and distance of farm to the home of the grating center.
10	Cassava Cake breaking and particle sieving	2	Depending on human strength and the size of the holes on the sieving machine.
11	Toasting	2.5	This depends on the strength of the toaster and size of toasting pan.
	Total	**35.23**	1 day, 11 hours, 13.8 minutes.
	Human active hours (Total hours minus average fermenting hours)	**11.23**	This is 3 hours above normal Nigerians' office working hours.

Table 2: total time and man net time in hours using Micro controller based Automated cassava processing system to process 25kg of garri from 75kg of cassava.

S/N	processing activity to produce 25kg of Garri fro 75kg of cassava	Average time(hrs)	Comments
1	Harvesting(man input)	1	This Depends on the soil type, nature of roots and human strength.
2	Transportation(man input)	0.333	20 minutes, depending on nature of road, transportation means and distance of farm to the home of the farmer.
3	cassava Loading to an Automated machine(man input)	0.033	About 2 minutes
4	Peeling by robot arms	0.5	30 minutes using using 5 peeling robot arms.
5	Automated Washing	0.083	5 minutes.
6	Grating and bagging	0.5	30 minutes. Grating and bagging happens simultaneously
7	dewatering and fermentation	24	Fermentation and dewatering take place simultaneously
8	breaking of cassava cake	0.083	5 minutes
9	Sieving	0.083	5 minutes
10	Toasting	0.167	10 minutes
	Total	**26.782**	1 day, 2 hours, and 4.692 minutes.
	Total minus the average fermenting hour (the farmer only waits for fermentation to complete)	**2.782**	This is about 2 hours of normal office working hours in Nigeria.
	Total human input hours(summation of hours of activities from S/N number 1,2 and 3)	**1.366**	

Below in Table 3, is a combination of table 1 and 2

Table 3: combined activities of cassava processing into garri and the corresponding time for both man-mechanical system and the automated system.

S/N	processing activity to produce 25kg of Garri fro 75kg of cassava	Average time(hrs) by mchanical system	Average time(hrs) by automated system	Remark
1	Root uprooting (Harvesting)	1	1	For both systems
2	Transportation. (15.2 km)	0.333	0.333	For both systems
3	cassava Loading to an Automated machine(man input)	0	0.033	For automated system
4	Cassava bark Peeling	2.5	0.5	For both systems
5	Washing of peeled cassava	0.5	0.083	For both systems
6	Transporting peeled roots to and back from the grating site(30km)	0.666	0	For mechanical system
7	Grating and bagging	0	0.5	Combined in automated system
8	Grating of cassava roots	0.5	0	Occurs separate in mechanical system
9	Bagging of grated roots	0.083	0	Occurs separate in mechanical system
10	Pressing of bagged pastes	0.5	0	Occurs separate in mechanical system
11	Dewatering and Fermentation of dewatered paste	24	24	For both systems
12	Transportation fro grating site back to the house	0.666	0	For mechanical system
13	Cassava Cake breaking and particle sieving	2	0.083	Occurs simultaneously in mechanical system only
14	Sieving	0	0.083	Occurs separately in Automated system
15	Toasting	2.5	0.167	For both systems
16	**Total**	**35.23**	**26.782**	For both systems
17	**Total minus the average fermenting hour (**the farmer only waits for fermentation to complete)	**11.23**	**2.782**	For both systems
18	**Total human input hours**	**11.23**	**1.366**	For both systems

Below in figure 3 is the graphical representation of table 3.

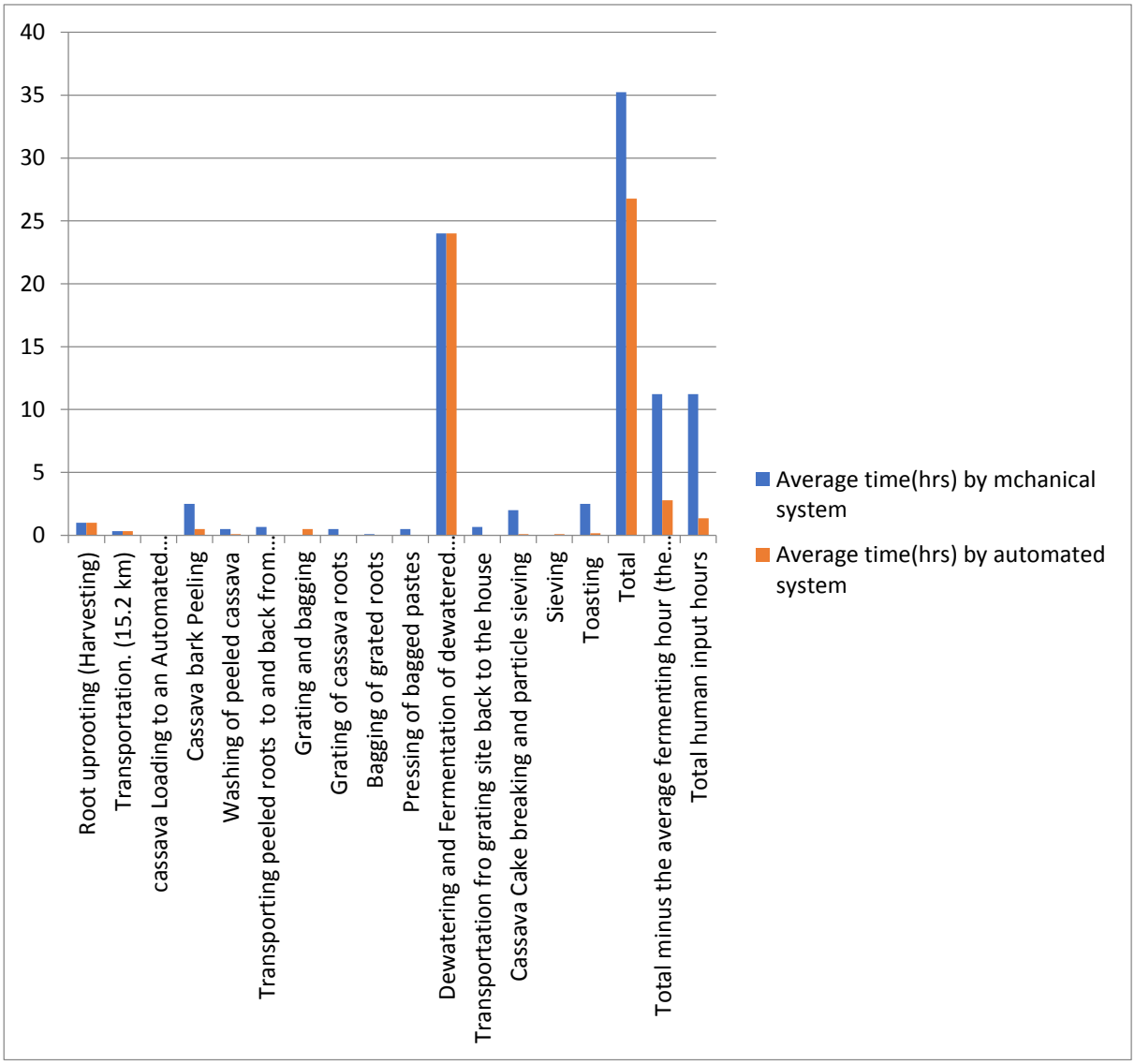

Figure 3: Graph of the combined activities of cassava processing into garri and the corresponding time for both man-mechanical system and the automated system.

VI. Discussion

Nigeria produces about 59 million tones of cassava. 74% of these 59 million tons (about 43.6 million tons) are processed into garri in the rural areas. Only about 14.5 million tons of garri are processed from the 43.6 million and 29.1 million are lost as waste during the process. This huge amount of waste is not noticed because they are disposed in small quantities, at different times, in scattered farms, scattered homes and scattered processing centers. None of these waste disposal points have a bio fertilizer production system. There is also no centralized cassava waste disposition points for collection.

In the past 10 years the highest fertilizer consumption of Nigeria is 1.5 million tons. The same country generates bio-fertilizer to the tone of 29.1 million tons every year from processing cassava into grrri. 29.1 million tons is about 19 times (1,940%) more than the highest quantity of fertilizer consumed in Nigeria per year for the past 10 years.

It is not only the bio fertilizer that is lost. Time is also lost. From interviews, observations and hands-on we found out that for a farmer to process 25kg of garri by a man-mechanical system which is the predominant system now, takes a total of about 35.23 hours and a man active hour of about 11.23 hours. This is illustrated in the table 1. To produce 25 kg of garri, 50kg of cassava is lost as waste. It takes also the same time of 35.23 total hours and 11.23 man active hours to produce 50kg of cassava waste.

The population of the rural Nigeria is about 99 million (48.04% of the total population). The average household size of the rural area is 5.42 individuals [30]. If we assume and exclude the 0.42 out of the 5.42 as infants

who can't process cassava, we have an average of 5 persons per household that are involved in cassava processing to garri. These 5 out of 5.42 amounts to about 91.33 million persons out of the 99 million of the rural population.

Using table 1, Let us calculate the number of hours it takes to produce 29.1 million tons of cassava waste every year in Nigeria. 29.1 million tons is 29,100 million kg (29.1 X 1000). We divide 29,100 million kg by 50 kg to get 582 million . 582 million is the number of 50kg in 29,100 million kg. let us multiply 582 million by 35.23 hours to get 20,503.86 million hours. This is the cumulative total hours used to process 29.1 million tons of cassava waste per annum. To get the active human hours, we multiply 582 million by 11.23 to get 6,535.86 million hour. This is the cumulative human active hours used to produce 29.1 million tons of cassava waste per annum.

From table 2 the automated cassava processing system take a total of 26.728 hours to produce 50kg of cassava waste. If we remove the fermentation hour, which is 24 hours, that is seen as an idle hour, we have active 2.728 hours for the automated system to produce 50kg of cassava waste that will be pushed into the biofertilizer rector to produce bio fertilizer. From table 2 the man active hour in the automated processing system is just 1.366 hours.

If we compare the man input in the two system of processing 50kg of cassava waste or 25kg of garri, we have 11.23 hours from table 1 and 1.236 from table 2. There is a difference of 9.994 (88.99%) hours which is man hour gain in processing 50kg of cassava waste using the automated system.

VII. Conclusion:

Before the introduction of the diesel and petrol engine powered grating and dewatering machine, farmers used hand grating machines and wood cage arrangement to grate cassava and dewater the grated paste respectively. The labour was too intensive and hazardous. Immediately the grating engines and dewatering machines were introduced, the hand grating and dewatering system was immediately forgotten. Today the hand grating machine is no longer in use.

The hand grating machines and dewatering system was in every home. Today the grating engines and the dewatering machines are not in every home but only in processing centres. All farmers take the cassava to the cassava processing centers.

The micro processor based automation of cassava processing system can be installed in communities' cassava processing centers. Farmers will take their harvested cassava roots to such centers were their cassava will be processed into garri. The automated system will save them time and labour.

The cassava wastes that the farmer use to scatter around due to the farms processing activities that takes place in different locations will be done in one location. In the same location, the wastes of the different processing activities will collected by the same processing machine and channelled to a biofertilizer reactor for fertilizer production.

The automated system will remove the farmer from the human labour of cassava processing. It will save the farmers' time. It will produce enough bio-fertilizer that the farmers need within the locality of the farmers and very close to the farmers' farm at almost no cost. This bio-fertilizer will aid the farmer to production more organic food using organic fertilizers. This fertilizer processing system is renewable.

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