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GARRI PROCESSING

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ABSTRACT

The production of Garri, the staple carbohydrate of West African nations, requires a time consuming and labor intensive process in order to transform the raw material, cassava roots, into the finished product. A garri processing machine was chosen as a focus project for RIT's Multidisciplinary Senior Design program in the sustainable systems track. The first two sub-processes of producing garri were identified as being particularly difficult and time consuming, so a machine designed to automate each of these processes was developed. A peeling machine was successfully developed to meet or exceed all needed specifications. A grating machine was also developed, however, further design iterations are still needed to meet all requirements.

The goal of the project was to design and manufacture a garri processing machine affordable to lower class families in Nigeria. The device would improve upon one or more of the inefficient processes related to the processing of garri. A discussion with the customer provided details regarding methods and time estimates for each step. The two steps of peeling and grating chosen for concentration were selected based on the given information and the team's ability to make a significant improvement. The peeling process traditionally takes three to four people, three to four laborious hours of peeling the monthly supply, utilizing only a standard kitchen knife. The current grating method involves renting a machine that takes about one half hour to one hour to perform the entire grating for a month's supply. While the grating operation itself is relatively quick, families can wait up to a full day for the machine to arrive at their home.

INTRODUCTION

The Garri Processing Project was suggested by RIT alumnus, Eze Kamanu. Eze grew up in West Africa and has been involved first hand with cassava/garri processing. Eze identified current production methods as being time-consuming and labor-intensive.

The primary objective of the project was to develop a device capable of peeling and grating cassava. This machine should reduce processing time and labor required for peeling. The product should also eliminate the reliance on a shared grating machine for West African families. This should save time and money associated with renting the machine. Finally, the product should be durable, easy and safe to use, and affordable to lower class families.

Garri is the staple carbohydrate of West African nations. Garri is a fine grain and can be made into breads, crackers and pancakes. Garri is produced from cassava, tuberous roots with thick skin and dense flesh. An average family of six produces approximately 50 kg of garri per month; this quantity requires about 400 cassava roots. Traditional processing includes six steps to achieving the final product of garri: peeling, washing, grating, drying, sifting, and frying.

The expected benefit of the Garri Processing Senior Design Project is to improve the quality of life for approximately 8-million Nigerian families by providing more efficient, economical methods for garri processing.

CONCEPT GENERATION

The concept generation for the group began with a benchmarking analysis of products available on the market that could be applied to processing cassavas. Machines currently available in West Africa and those in the United States were compared to generate ideas on how to effectively peel and grate the roots. The most popular grating machine currently used in West Africa can be rented, posing an accessibility issue as customers cannot use it whenever they want. Taking into consideration the customers the group was looking to market to, it was decided that the best approach to designing machinery for such processing would involve manual power to keep cost down and provide allowance for using the products in any setting. The two most effective products evaluated for benchmarking were an apple peeler and a food mill.

Initial concepts generated ranged from one large machine that would combine peeling and grating in one unit, driving cassavas on rollers to more basic concepts like abrasive rollers with teeth rubbing the skin off. All concepts were scored and ranked in a matrix to determine which would be chosen for the initial concept. Concept scoring involved comparing the critical features and components of the conceptual designs with those of the benchmarked products. The concept initially selected involved both peeling and grating, incorporating both a blade similar to that on an apple peeler and a fine grating disc. The cassavas would be fed through an opening in a box while the user cranks a handle to turn the blade arm and disc. The cassava would be peeled and then grated into a fine grain and deposited into a receptacle at the bottom of the box.

After the initial concept was presented, professors and students commented on improvements and considerations for the design including: adjusting the grating disc so that it would sit off-center of the central axis for effective grating, and altering the drive of the blade and disc to motorized power rather than manual. Upon reflection of the critique of the original concept, the decision was made to simplify the design by breaking up the peeling and grating into two separate, smaller machines. This would make the goal of creating products within the set cost range more reachable.

The change in direction of the project required the original benchmarking analysis to be revisited, with smaller machines. The apple peeler idea was maintained as a basis for what to use to remove the skin of the cassava. Further brainstorming and research led to the development of using a rotating cone with teeth for grating. Similar products are presently available, but the initial concept required

modification to meet the constraints of the project. The products on the market now work for smaller fruits and vegetables like apples and potatoes. The length of the cassava caused concern and presented an opportunity for improvement for the apple peeler to accommodate larger pieces of roots. By purchasing only the cone for the grating device, more flexibility could be incorporated into the design of the apparatus. This allows for appropriate development of safety features.

MANUFACTURING

A modified version of the apple peeler design found in the benchmarking process was adapted to meet the needs of peeling cassava. The existing peeler design consisted of a suction base so that it can be attached to a relatively smooth surface. This was the first point of the peeler to be modified so that the device would be capable of being affixed to a multitude of table surfaces and thicknesses. The second design modification came after realizing that the cassava could potentially outweigh the ability for the three-prongs to support the load; for this, a spring support with a roller bead was devised to support the cassava. This provides support for cassavas while being driven and rotated into the peeling blade. To achieve both of these feats, a c-clamp was cut and welded out of 1" steel bar stock and attached to the bottom of the peeler using the pre-existing threaded holes from the suction base. The support system was created out of this same bar stock by heating and bending two upright posts which the springs and roller were strung between. This support structure was welded to the end of the c-clamp to maintain a flush table-to-peeler tolerance and to reduce the need to attach it to the peeler separately from the c-clamp.

A structure to house and rotate the cone for the grating portion of the project was also fabricated. A method for rotating the cone was accomplished by creating a drive mechanism with six teeth to turn the cone on a central axis. The central axis, for which the cone rotates on, consists of a carriage bolt driven by a handle made of glass-filled nylon. The whole assembly is supported by a pipe, in which, the carriage bolt rotates. From here, a base was constructed out of steel bar stock. The base includes a c-clamp to attach the device to different work surfaces. The base is also designed to provide enough clearance between the cone and the work surface to allow for the cassava to exit the cone without backing up. The rotating blade of the grating machine posed a safety risk towards users so additional manufacturing designs became necessary. The shield and chute designs chosen both provide protection from the moving grater cone, and assist in directing the cassava into the moving grater. The chute adds additional safety in that it is 6" long and narrow

enough that a person could not reach their hand and fingers into the moving parts. For prototype purposes, the shield consists of a steel can and the chute is constructed out of a thick cardstock tube. A grinder was used to cut the can so as to accommodate the cardboard chute. The two were adhered together and then the chute was trimmed to allow the cone to fit in the new safety housing. The shield and chute assembly are attached to the rest of the machine using machine screws.

The material chosen for these two designs were for prototype purposes only. The materials were easy to manipulate and readily accessible. For the intent of mass production, other materials such as plastics for the shield and powdered metals for both the grater and peeler would be preferential.

TESTING

Testing was necessary to determine the success of the selected peeling and grating designs. The time and effort to perform these tasks are the most critical improvements to be made. Testing methods were designed to identify the strong and weak points of each design and confirm that product specifications are met.

Cycle Time:

Time trials were performed to obtain the average cycle time for both the peeling and grating devices. Due to the inability to obtain cassava in the Rochester area, all time trial tests were performed with a yucca root, which is very similar in size, shape, and skin and flesh texture. Yucca samples were prepared in four inch sections. The diameter of each end was measured and recorded along with the mass of each sample. Each sample was peeled, weighed again and then grated while times were recorded for the peeling and grating portions of the testing. The average length of a cassava is actually six inches long making it necessary to weight the times recorded for both peeling and grating. The time recorded to grate each yucca sample was multiplied by a factor of 3/2 in order to account for this variance. This weighting factor is appropriate because there is very little, if any, time required to change over and begin grating a second cassava. When peeling, two time measurements were recorded: the average time required to load and unload the peeling apparatus, and the average time required to actually peel each yucca sample. To obtain an average cycle time for the peeler the peeling time was multiplied by a factor of 3/2 and added to the loading time because the loading time has a negligible scaling factor compared to the actual time to peel.

Percent Mass Removal:

Using the mass of each sample before and after the peeling process, the percent mass removal was calculated. A similar test was performed in which a yucca was peeled manually using a knife to determine the percent mass removal using traditional methods. There was no time limit on the manual peeling to insure safe and appropriate usage of the knife.

Usability Testing:

A usability test was performed in order to determine the feasibility of these products being used in place of the traditional methods. A request was made to the RIT Internal Review Board for Human Subject Testing and all necessary paperwork was filled out so that human testing could be conducted on RIT grounds. A group of 20 random participants were presented both the peeler and grater and given a portion of a yam. They were told what each machine did but were not given instruction on how to use either. When the user was finished, they were asked to fill out an exit survey which was used to determine whether the machines were intuitive and what their likelihood of using them would be.

RESULTS

Completion of usability studies and time trials allows for an analysis of the results, comparing the test findings to the product specifications. The specifications under investigation in the user trials included intuitive product use, ease of use as a function of the force required to operate the devices, and the users' product preference (the marketability of the product). The time trials, conducted by the engineering design team, investigated the average time to peel and grate cassavas.

User Surveys:

The results of the user studies were favorable. For both the peeler and the grater, the target specification for acceptance was 100% of users, with a marginal value of 75%. While the team was willing to accept 75% for product preference and ease of use, the goal was to achieve as high a value as possible, understanding that some users may favor a product they are more comfortable or familiar with.

The peeler studies (figure 1) found that 95% of users could operate the peeler without instruction and 100% of users were comfortable with the amount of force required to peel a yam. When users were asked about their product preference, 90% of users would choose the peeler over a standard kitchen knife, 5% of users would prefer to use a knife, and 5% were either undecided or had never peeled anything with a knife and thus had no basis for comparison. These

findings fall well within the specified range of acceptance.

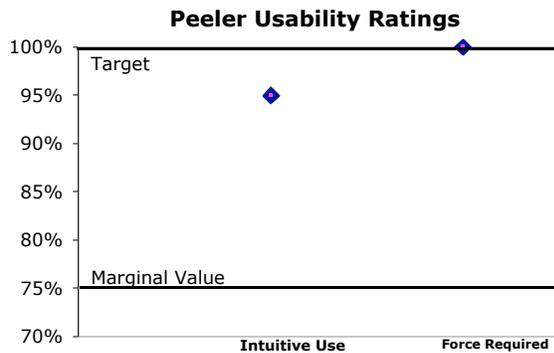


Figure 1. User survey results of peeler

The user trials conducted on the grater (figure 2) resulted in a varied response from users. While all of the users found the use of the grater to be rather intuitive, the users’ product preferences were quite varied. The amount of force required to operate the grater appeared to be a limiting factor; 65% of the

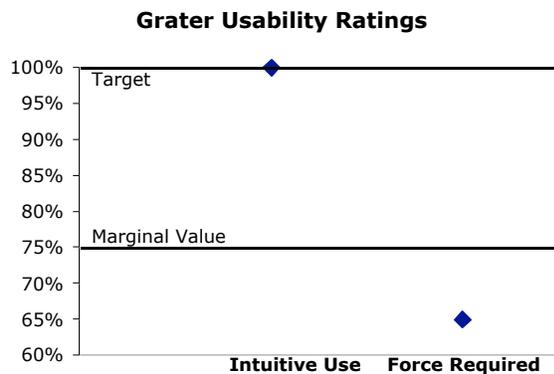


Figure 2. User survey results of grater

users were comfortable with the amount of force used and believed they would be able to grate 50 cassavas or yams with this device. Only 50% of users indicated that they would choose this grater over a cheese grater, 30% would choose the cheese grater, and 20% were either undecided or had never used a cheese grater and had no comparison. It is believed that there is a strong correlation between product preference and the amount of force required to use the grater. Many of the user comments on the surveys indicated force as a problem; grating 50 cassava/yams could be tiring or require multiple breaks. If the force is reduced, it is likely the product would be more widely accepted. The force and product preference ratings fall below the 75% acceptance and resulted in brainstorming some modifications to the design and recommendations for future work.

Mass Removal Comparison:

The cassava peeler resulted in an average mass removal of 12.7% of the original mass. When peeled with a knife, the average mass removed from the cassava was 15.9%. This is a pass/fail test and the peeler passes since the amount of skin and flesh removed is less than that of traditional methods, using a knife.

Cycle Time:

For peeling, the marginal and target specifications were 30 and 15 seconds per cassava, respectively. Based on the production of 100 cassavas per week per family, these specifications would yield a product that was capable of peeling 100 cassavas in 25-50 minutes (see figure 3). The average time to peel a cassava, computed from the trial data, was 22.75 seconds or approximately 38 minutes spent per week peeling cassavas (see figure 4). With traditional methods requiring between two and a quarter and four man-hours per week to peel cassavas, this method will reduce processing time by over 70%.

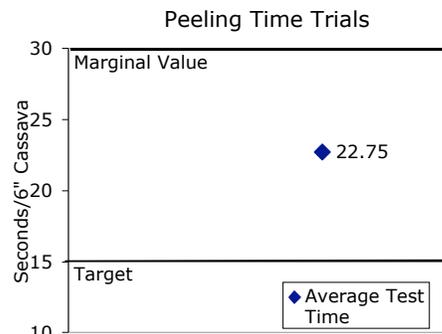


Figure 3. Peeler time trials

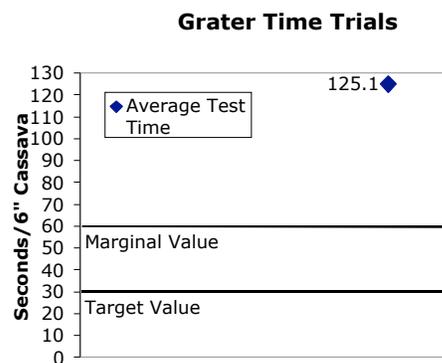


Figure 4. Grater time trials

The product specifications for the grater require a cassava to be grated in, at most, 60 seconds, with a target of 30 seconds. These specifications would ensure that the product could grate a week’s supply of cassava in a maximum of 1 hour and 40 minutes. The time trials produced an average grating time of

125.1 seconds per cassava. This is twice the marginal acceptable value and would require over 3 hours and 20 minutes to grate 100 cassavas.

The user studies and time trials conducted for the peeler indicate that the device both performs to product specifications and has user preference and acceptance. The grater, on the other hand, requires some modifications to increase user acceptance and presently falls outside of the product specification range for acceptable grating time.

CONCLUSION

The peeling machine significantly reduces the time associated with peeling cassava for garri production

while making the entire process more bearable for the user. The current design of the grater proved inefficient in reducing either the time or effort required. Future work needs to be performed in order to stabilize the assembly and make the handle easier to turn to reduce the required force. This concept shows potential though, that with a few more design iterations it could become a feasible design.

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