To: Dr. Trevas and GTA

From: Rural Food Processing Capstone Team (19F16)

Date: 28th February 2020

Subject: Implementation I memo

The Rural Food Processing Capstone Team is currently on track to produce the final dispensing and rolling subsystem deliverables to the client. The team has produced a low fidelity model, a plexiglass and 3D printed model, and a wood prototype which is the most similar to the final design the team will be delivering to the client. The team has successfully determined the manufacturing of the device prototypes (plastic/plexiglass as well as wood) and has worked through design iterations in order to arrive at the current state of the design. The team has also determined the plan for future implementation of the design including manufacturing, schedule, and budget. All of these will be addressed in this memo further.

1 Implementation

The implementation memo has a detailed information about the manufacturing process that the team has used to create the prototypes. In addition, the memo includes details on future manufacturing plans and design changes with a breakdown of the budget and schedule for the remaining time of the semester. The main changes in the design are to account for the imperfections in rolling, including the side rails that guide the rail bar. Moreover, the team has not decided on the handle for the wooden prototype, which is one of the main focus points in the design moving forward. The schedule main deliverable milestones are the manual as well as testing. The total budget left remaining is approximately $1182, or approximately three quarters of the total overall budget.

1.1 Manufacturing

Plexiglass Prototype

The team has manufactured two prototypes. The first prototype was made from plexiglass. The team determined that some sort of rigid plastic would be ideal to construct the first prototype, especially because the team has easy access to the Maker Lab in order to 3D print some of the parts with more complicated geometry and precise cutouts. The team determined to utilize plexiglass beyond the 3D printing due to easy accessibility and the convenience of the clear plastic to observe any issues with assembly after manufacturing, as well as plexiglass being cost efficient and light weight.

Figure 1: Plexiglass Prototype of Roller

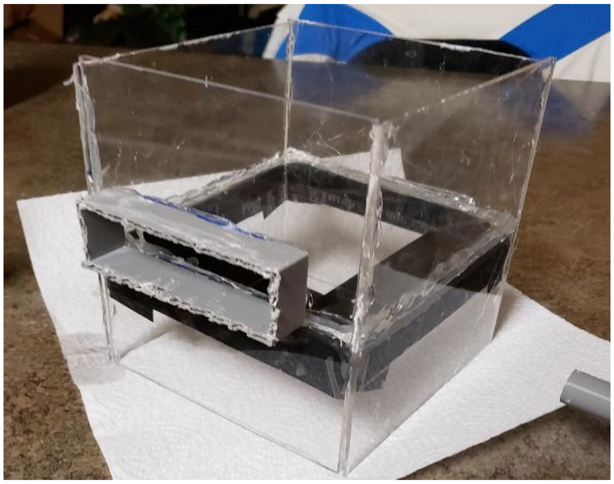

Figure 2: Plexiglass Dispenser

The team started manufacturing by breaking the plexiglass to meet the drawings that the team created in CAD modeling using the Dremel, which was primarily required in order to cut the plexiglass to size in terms of manufacturing, as seen in the base of the roller in Figure 1. The team also required fastening of the components for the original design of the roller and dispenser. For the roller, this was achieved through machine screws, washers, and nuts. Figure 2 shows the hot glue and tape that was used to assemble the sides of the plexiglass that were cut to size. In addition to cutting the base to shape, the team created holes using Dremel in the base for the fasteners. Beyond the manufacturing involving the plexiglass, the team required use of the 3D printers in the Maker Lab in order to print the side rails, the end bracket, the roller bar, the roller bar bracket, and the handle in this prototype.

Roller Wood Prototype (Final Design):

Beginning of the second semester of the capstone, the team has decided to build a second prototype based on the client request. The second prototype was manufactured from wood. The team ordered ½-inch plywood, a dowel rod, and ¼-inch plywood. Those materials were used by the team to manufacture the prototype based on the same dimensions that were used to manufacture the plexiglass prototype. First, the team used a table saw to cut the plywood into the dimensions required for the base, rails, and the falling hole for the roll to fall in, afterwards the team used the drill to drill out the holes where the base of the design were nailed with both of the side rails.

Figure 3: Wooden Roller Prototype

Figure 3 shows the completed manufacturing of the new roller base using the manufacturing processes above.

Caulking gun dispenser (Final dispenser design)
The team came up with a new dispenser method due to the original design manufactured in the first semester not performing as expected. The new design is a simple caulking gun device purchased from Amazon with a price tag of less than twenty dollars. The caulking gun shown in Figure 2 has a three-stage disassembly process that is convenient for cleaning the dispenser. It was determined to be user-friendly due to the low number of components as well as the accessibility for cleaning the system to improve the food safety of the system.

Figure 4: caulking gun disassembled

Engineering Requirements Considerations
In regards to calculations and considerations involving engineering requirements for the project, the team considered the requirements detailed in the ERs, CRs, and TPs Revamp memo completed previously. For low weight, the team remained under the target weight of the roller for all the various prototypes, along with remaining within the bounds of the base footprint. Each entire system remains under budget when considering the cost to produce one product rather than the cost of bulk, raw materials. Smooth edges will be achieved once the team determines the most effective way of rounding out the edges on the wooden roller to prevent splintering. The center of gravity will be calculated via CAD software once the final, updated prototype has been fully designed in SolidWorks; the first prototype was determined to have an adequately low center of gravity so the team anticipates minimal change with the new material being implemented). The team has also completed various deflection and FEA calculations in order to determine appropriate thicknesses of the different materials in order to account for the factor of safety.

1.2 Design Changes

The design the team has settled on very closely represent the initial prototype made. Major changes stemmed from request from the customer along with the dispenser system not working properly. The team was ale to use previous concepts and new materials to meet the customers request and make all systems fully functional.

1.2.1 Design Iteration 1: Change in roller subsystem discussion

Figure 5: Low Fidelity Prototype

The very first low fidelity prototype is shown in Figure 5, which is a simple cardboard representation of the design intent of the team. This functioned as a proof of concept for the roller, which could roll stiff, cylindrical contents across the base of the roller. The team primarily encountered problems with the thickness of the mat used in the roller base. While the team was expecting to produce rolls approximately cm in diameter, the base was only capable of producing rolls that were double to triple this result; additionally, the inconsistency in the final rolled product was of concern to the team moving in to the higher fidelity model. There was also a large amount of deflection in the rails, which the team expected due to the base's construction out of cardboard.

The high fidelity prototype was constructed out of plexiglass and 3D printed materials, as described in the manufacturing section prior. The team implemented a new silicone sheet that was approximately 1/10th of the thickness of the original mat for the roller in order to produce as tighter roll. Additionally, the length of the track and overall dimensions of the base were reduced to more closely reflect the approximate 5cm x 5cm dimensions of the cocoyam leaves. The team assumed these dimensions could fluctuate up to approximately double (10cm x 10cm) considering the variability expressed when observing the demonstration during the first semester. Accordingly, the team factored in a total of 20cm of variability, with half of the tolerance applying to either side, and another approximately half of this half accounting for the space lost in due to fastening the rails. Other than the material changes and the dimensional changes, the design remained largely the same due to the performance of the device.

Figure 6: Wooden Prototype

The current design of the roller subsystem incorporates many changes. These are largely attributed to the manufacturing processes and fastening techniques used with yet another different material. The team was satisfied with the plexiglass prototype as it met the requirements, but the client expressed explicit interest in a wooden prototype not for mathematical engineering purposes, but because of accessibility in Africa to wood versus plastic. Because of this, the team has been working to create a wooden version of the design and is still in the process of performing final calculations to optimize the thickness of the material and the adherence to the safety factor before the final product. This design was made using the plexiglass prototype as a template for dimensions because the team had already optimized the dimensions as described above. The rails, as seen in the roller in Figure 6, are altered from the “L” shape in the previous design and instead are fastened to the side of the now thicker roller base in order to eliminate wasted material. The end of the roller was also shortened for the same purpose of eliminating wasted material due to that portion of the base serving no purpose in the previous prototype. The team is currently working through analyses to determine the optimal number of staple fasteners for the wood in order to produce a stable and reliable base.

The team was able to validate these design changes by using the Solidworks model to test for the design’s stability. With one of the engineering requirements being stability the team used Solidworks to find the devices center of gravity. The new prototype had similar dimensions as the Solidworks model previously used. With the dimensions being the same the team was able to find the center of gravity and apply it to both models. If more drastic changes had been applied the team would have used another method in finding the devices center of gravity. As seen in Figure 7 the center of gravity for the device is exactly in the middle allowing for it to be very stable.

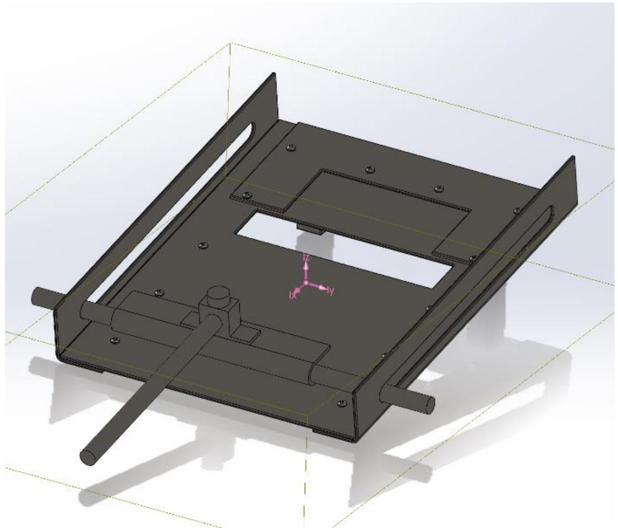

Figure 7 Center of Gravity

After this analysis the team was able to show that both models would meet this requirement. Further testing will be done on strength and its life cycle since the materials have very different properties.

1.2.2 Design Iteration 2: Change in dispenser subsystem discussion

Figure 8: Original Dispenser

The original design of the dispenser was much like the roller: composed of cardboard and very large, as shown in Figure 7. The team immediately knew the design needed to be scaled as well as made from a different material.

Figure 9: Plexiglass Dispenser

Figure 8 shows the same design scaled to a smaller sized to accommodate a smaller volume as well as the design being made out of a different material. The primary problem with this iteration was that the cocoyam mixture was unable to be forced out of the nozzle when pressure was applied to the handle of the dispenser. The force was distributing across the cocoyam and the small nozzle prevented flow through the system.

As discussed above, the team completely moved away from the initial dispenser to a caulking gun in order to overcome the back-up issue the team encountered with the nozzle. The caulking gun selected was selected for the easy disassembly/assembly for cleaning purposes, as well as the 12:1 mechanical advantage the gun provides. The team will be conducting an investigation as to the viscosity of cocoyam in the next few weeks as the equipment is available in order to determine the precise mechanical advantage that will be needed in order to dispense the cocoyam effectively.

2 Future Implementation

With a functional prototype built the team can now focus on other upcoming deliverables. The next major step for the team will be to start testing and have our mentor use the device for any critique. Once this is done the team can modify and perfect the design as the final product. The team is currently on track with this plan and hopes to have a perfected fully functional device by the end of the semester.

2.1 Further Manufacturing and Design

The team needs to modify the second prototype due to Manufacturing imperfections. The wood porotype was unable to roll with the silicon sheet due to the friction between the wood and the silicon sheet. Therefore, the team will apply palm oil to reduce the friction and allow the silicon to roll over the wood. In addition, the railways were not evenly cut. Therefore, the team will need to reduce the pumping via sanding. Moreover, the team has not decided on what material to use for the handle. The team will conduct more analysis on using either a 3-d part or a meatal rod for the handle based on the engineering analysis of cost and durability.

2.2 Schedule Breakdown

This semester the team has worked to complete both a wood and plastic prototype while running test to check the designs validity. The team has been on track with the original Gantt chart even with the new requirement of building a wooden prototype. The team is now focused on testing the device along with creating an owner's manual. Testing the device will begin on March 2nd with the following test following the outlined schedule in the test procedures memo. With the addition of the wooden prototype the team is ahead of schedule allowing them to refine the final design. The upcoming deadlines can be seen in the Gantt chart provided below.

Website Check	Milestone	Team	100%	2/18/2020	1
Assign Sections of Hardware Review	Goal	Team	100%	1/27/2020	1
Edit Hardware Review	Goal	Samantha	100%	2/9/2020	1
Hardware Review	Goal	Team	100%	2/11/2020	1
Check Materials	Goal	Musab	100%	1/27/2020	1
Start Building Final Design	Milestone	Team	75%	1/28/2020	20
Check Testing Procedures	Goal	Humoud	100%	2/20/2020	1
Test Design	Goal	Team	20%	3/2/2020	14
Start Operations Manuel	Goal	Team	10%	2/28/2020	15
Fix Wooden Prototype	Goal	Nygel	0%	3/1/2020	10
Have Jacky use design	Goal	Team	0%	?	?
Implement Jacky's ideas	Goal	Team	0%	?	?
Title 3					
Assign Sections of device Summary	Goal	Team	0%	3/14/2020	1

Figure 10 Gantt Chart

A major milestone the team is still trying to schedule is time to meet with our mentor Jacky and have her use the device. We previously had time allocated to this, but she had to cancel at the last minute. Having her test, the design will allow us to fix the design to better fit the user's needs. The team had hoped to have this accomplished before testing but due to no response from Jacky at this point, we will begin testing the current designs. The rest of the team's schedule will follow the Gantt chart created at the beginning of this semester.

2.3 Budget breakdown

The budget provided at the start of the capstone project was $1500 from Gore. After building prototypes the current amount left is $1182.21. A breakdown of the products purchased can be found in Table 1 below.

Table 1 Current Budget

Expenses				

Low fi proto		$41.63		
Cline Library				
	1st rail	$ 8.40		
	2nd Rail	$ 8.40		
	Plunger	$ 15.13		
	Nozzle	$ 18.54		
	End bracket	$ 9.45		
Amazon				
	1 Silicone + 6 Plexiglass	$ 60.09		
	2 Plexiglass	$ 17.32		
	Empty caulking tubes	$ 12.75		
	Piping Bags	$ 9.99		
	Parchment Paper	$ 4.99		
	Caulking gun	$ 19.95		
	1/2-inch Plywood	$ 32.70		
	Dowell	$ 13.01		
	Cocoyam Powder	$ 11.00		
	Silicon Sheets	$8.49		
	1/4-inch Plywood	$ 19.29	Budget	1500
Home Depot			Cost	$317.79
	Hardware	$ 6.66	Budget Left	$1,182.21

A majority of the money used so far has been spent on building the plastic and wooden prototypes. Testing will be the next expense the team will encore. The team will be testing the characteristics of cocoyam in Dr. Beker's lab which will have to be paid for. The exact cost has not been determined yet but is expected to be under $300. The materials for the final iteration were ordered with the prototyping materials so there will be no cost associated with building the final iteration.

The bill of materials for the wooden prototype was similar to the plastic model. The biggest change as seen in table 2 is the material being wood. With the change in material the roller is still within the desired price range coming to a total cost of $22.99.

Table 2 BOM Wood Model

BOM Wood Roller					
Quantity	Price Per Unit	Description	Function	Material	Dimension (in)
1	$3.26	Roller Base	Hold Cocoyam	1/2" Plywood	12"x12"
2	$3.26	Side Rails	Guide Roller Handle	1/2" Plywood	12"x3"
2	$1.32	Roller Handle	Provide Grip for Rolling	5/8" Dowell Rod	1'
1	$5.65	Bracket, Belt End	Secure Silicon Sheet	1/4" Plywood	6"x12"

6	$0.50	Bolts/Nuts	Fasten	1" bolt/Nuts	
16	$0.003	Staples	Fasten	1-1/4" Staples	
1	$4.25	Roller Belt	Roll Leaf	Silicon Sheet	6"x12"
1	$0.71	Belt Clamp	Clamps Belt to Handle	3D Printed	7.8"x1.6"0.86"
1	$0.17	Clamp Top	Secures Handle to the Bracket	3D Printed	1.25"x2.75"0.78"
1	$19.95	Caulking Gun	Dispense Cocoyam	Metal/Plastic	6"x1'
Total	$42.94				

The largest expense for the wood roller prototype is the plywood. All the other material are very inexpensive, so if a cheaper source of wood can be located the price of the design wood drop further. The caulking gun also was very expensive compared to the other material with it being about half the total cost. A cheaper caulking gun that does not disassemble will be sourced for five dollars improving the cost greatly.