Student Solutions for Leaf Drying: A Collaborative Approach to Enhance Moringa Production in Ghana

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This paper expands on a project that seeks to address the need for an updated mechanical leaf drying system for local farmers in Ghana, Africa. Working with the local organization, Moringa Connect, we were able to connect and identify potential areas of improvement within the current existing system. This project involved aspects of design, fundraising, and the construction of a rotating metal hopper. This hopper was identified as a solution for a crucial pinch point currently seen in the processing of the leaves from a wet stage to the final dry product. The design and construction process had a multidisciplinary approach requiring expertise from different fields, such as BioResource and Agricultural Engineering, Electrical Engineering, Construction Management, and others. The implementation of this prototype represents a tangible asset that will help in producing a viable option for the local farmers of Ghana to enhance their current production. As the project team continues its work, it is our intent to continually improve and refine our design to maximize the impact of this project, eventually providing a scalable and replicable solution to meet the client’s needs.

Key Words: Construction, Moringa leaves, leaf-drier, Rotating Hopper, Service Project
Background and Information

Moringa Connect is an organization that partners with over 5,000 local farmers planting and farming moringa trees primarily focused in Ghana, but with other operations located throughout Africa. Their farming process involves a 60 kilowatt array of solar panels powering three 10 horsepower water pumps that pump water from the local river into their fields daily. Moringa is a fast-growing plant, and they process around 1000 kg of wet leaves (including stems) a day. Once these wet leaves are harvested, they load up a truck and drive the leaves 9 hours to Accra, Africa where the leaves are then processed. Processing involves first removing leaves from the stems, then washing the leaves twice in both chlorinated and potable water. Next, they are put into a spin cycle to get rid of a large portion of the water, and finally they are placed in bed dryers that run off gas where they are flipped halfway through the process. Some issues in the current process are the transportation, human contamination, and meeting the production demand in the current dryers.

In November of 2023, we established initial contact with the Moringa connect team to talk about areas where our team might be able to help them. After the discussion, our team had a few options to select from, ultimately selecting to help out with the drying process of the moringa leaf production. The original plan the team settled on involved the fund raising, design, and implementation of a leaf drying system on the farm located in Ghana, Africa. We thought that this process would be attainable given the amount of time available, but we were wary as none of the team had any experience in anything of this nature.

Fundraising and Design
From the start, we knew that a project like this would require a lot of capital, we originally assumed around $5,000 for a prototype at Cal Poly, $3,000 for each person's flights, as well as a $500 cost for all vaccinations. We also assumed around another $500 for food and lodging, and finally $15,000 for material in the country. This all came to a total projected budget of $47,500. We had a starting budget of $25,000 from winning multiple student competitions as well as saving up extra money in our club budget over the past few years. This project involved 5 students both in MCAA (Mechanical Contractors Association of America) and in NECA (National Electrical Contractors Association), we started by reaching out to every Mechanical contractor in California sending over 200 emails and we heard back from 2 saying they would be willing to donate $6,000 dollars each to our project. Next, we began to reach out to all of the NECA contractors in California and we got pledges for over $17,000. This project didn’t seem so out of reach for us.

Next came the design stages. We decided that having each member of the team come up with 2 designs would be the best way to get multiple different design ideas out on the table and prevent us from having too many similar ideas. After reconvening with the team, we began by each drawing our designs on a classroom white board and discuss how each of the systems and parts of our designs would work together to dry the leaves. Ultimately, after hours of discussion, we settled on the idea of a rotating hopper as this would eliminate the need for flipping the leaves by hand and reduce the potential risk of contamination to the product. This idea also allowed for a lot of air flow over the leaves helping with the overall drying process. Once we had settled on the design type, we went back to the drawing board again having the team split up and come up with potential ideas for the system that would accompany our rotating hopper as well as how we would spin it. Ultimately, it was a previous physics professor at the school who had the idea of using a worm drive gearbox to help overcome the torque requirements needed to spin the leaves. Once we had the design for our rotating hopper we could get started on our hopper while we finalized our design for the enclosure it would rest in. We came up with the idea of using a cinder block enclosure in Africa because it was relatively cheap to build and would meet our specific needs.
We started by completing all the required woodshop and metal shop training in the CAED support shop before we began construction to ensure that we were being safe while working on the project. Next, we bought three 1/4 " thick steel plates and took them to the CAED support shop where we cut them on the CNC machine. During this process we had to make the design drawings in AutoCAD then upload them to the computer attached to
the CNC machine. After uploading we checked to make sure that all of our points along the outline were within our steel. After cutting these out we began to grind away any excess material and used a wire brush on a grinder to get rid of all the rust that had compiled on our steel.

The next part of our construction process was to put together the drum frame and attach the perforated steel to the outside. We first took our circular end piece and began to lay out where each of our tubular steel would be placed. After making sure the spacing was all symmetric, we used two sets of hands to hold the tube steel perfectly perpendicular to the end piece; meanwhile a third person began to tack-weld the tubular steel into place. After double checking that it was completely perpendicular, we completed the weld. A few hours later we had completed a rough frame for our hopper drum.
After the drum frame was welded together, we needed to attach our 1/16 “ perforated steel to the outside of the 6 ribs spanning between each of the circular end caps. We placed our perforated steel on top of our frame and began screwing the perforated steel into each of the ribs in the frames. After this was done, we cut a section of the perforated steel out from the drum to make the door of the hopper. For the door, we first built-out a frame, then proceeded by welding the perforated steel. Finally, attaching the hinges, the door was placed on to our rotating drum.
While putting together the hopper drum, we had a team working to build-out a metal frame for the hopper to sit on. The frame was designed to hold the hopper up using a mounted bearing that would connect to the hubs and 2’ rectangular tube steel. The frame was built one side at a time on the ground and after making sure that the right dimensions were correct, we welded together the frame using a MIG welder.

The next part of the process was one of the most time intensive, involving machining special hubs that would fit tightly against our drum and through the bearing; these hubs also had to fit into the worm drive. We started with a ¾” 2”, and 2-1/4 “ steel rod. We cut out two round circles from our steel plate on the BRAE shop’s larger CNC because the one in the CAED shop could not cut that thick of steel. Next, using our AutoCAD drawings on the steel circle, we zeroed the circular plates on the steel mill and began to use the coordinates in our drawing to drill 8 holes perfectly symmetrical around our center hole to allow for bolts to connect our hub to the outside of our drum. Next, we placed our rods into the center hole in each of our circle plates and, making sure they were perfectly straight, we welded them into place. After we placed our hubs in the lathe and began to turn down our hubs into two sections. Lastly, we placed each of our hubs back into the mill which allowed us to drill the keyway which would make sure our hubs fit perfectly into the gearbox. During this process we decided to make each hub identical so that way they would be interchangeable.
The last part was putting everything together. We began by attaching the hubs to each side of our hopper drum with the bolts through the holes we had previously drilled and threaded. Then, we placed bearings each on the hubs and lifted our hopper onto our frame and into place. Once the hopper had been placed, we measured where to attach our platform for the gearbox and motor, and then attached two platforms, one for each piece of the equipment. After, we drilled holes in the equipment platforms and placed the equipment into place making sure that everything fit properly. Lastly, we connected all our wiring and transformer and began to spin our hopper. A VFD (variable frequency drive) allowed for changing the speed of our rotation.

**Lessons Learned**

With the completion of the project came some invaluable lessons learned by the students. These lessons are something that no amount of time in the classroom can teach but that must be learned through real world applications. Three of the biggest lessons learn on this project were -

The first big lesson learned was - Define Scope from the beginning and with as much detail as possible. Although meetings were held at the very beginning of the project to try and define the project scope many times after meeting members of the team were not exactly sure what the scope was and exactly what was feasible. This in turn led to multiple times that the project scope had to be changed and with that came different designs and multiple changes to budget and logistical plans.

The second big lesson was - Continue constant communication with all parties involved in the project throughout the project. This was a lesson that was learned the hard way, with so much to do and often time multiple groups working on various parts of the project it was very hard to track everything that was going on with the project. This led to multiple occasions where part of the team was on different pages as far as the progress made and what needed to be done. This eventually got better however inefficiencies from this, and tight time constraints ultimately led to the project being downsized.

The third big lesson learned was - Divide and conquer. This was a lesson that was seen throughout the project and was probably the hardest to combat. As none of the team had any experience with this kind of work, many times we were all learning together. From the beginning we had trouble dividing up the work, partly because there was so much
administrative stuff that it made sense for one or two people to handle as to not misplace documents and for general understanding. However, later on the inability to split the work and really figure out who would be responsible for what ultimately led to a major decrease in the production rates of the project.

![Image](image.jpg)

**Conclusion**

In conclusion, this project sought to address the need for local farmers in Ghana, Africa, by providing a revolutionized leaf drying process that could not only save them time, but also money, through collaboration with Moringa Connect. The team overcame multidisciplinary challenges regarding design, fundraising, and construction to provide a rotating metal hopper that is able to change speed. Despite constraints regarding the changes in scope, this project was a valuable step toward providing data that could revolutionize leaf drying and improve quality control and production. The three biggest lessons learned were how important defining scope can be from the beginning of a project, maintaining constant communication with everyone involved with the project, and effectively delegating tasks throughout the project to keep production levels high. As the project wraps up the team’s commitment to refine the design, with the aim to provide a simply scalable product that will meet the needs of Moringa Connect and the farmers they partner with, offers valuable design concepts and information for future projects to continue expanding knowledge on this topic.