Avocado Oil Extraction in Leguruki

IDDS 2014 - Tanzania

Abstract

This paper presents the progress on developing an appropriate avocado oil extraction process for rural villagers in Leguruki, Tanzania. Avocados are a plentiful but low-value resource in Leguruki, with no perceived use except for consumption. Through discussions with users, avocado oil was identified as a potentially valuable product. Three initial avocado oil press prototypes were developed and brought to Leguruki to gather user feedback and explore community interest. While all three prototypes successfully pressed oil, a fourth prototype was developed that explored a new direction, rather than expanding upon any of the three previous directions. In addition, a solar dryer was developed, as drying avocado was a critical but unaddressed part of the oil pressing process.

Context

Background

This project was started at IDDS 2014 - Tanzania. The village of Leguruki was selected to be one of IDDS's local community partner villages, and was identified to have an overabundance of avocado. A team of five IDDS participants was faced with the open-ended task of working with Leguruki to capitalize on the amount of unused avocado in the area. The project continued at IDDS for five weeks, and is still under development by team members who remained in Tanzania post-IDDS.

Community Description

Located 48 kilometers from Arusha town, Leguruki is the administrative ward of Meru District in the Arusha region of Tanzania. Leguruki village is the name of the capitol village in the Leguruki ward. Leguruki has a population of 17,000 people, predominantly from the Meru tribe. Most citizens are small-scale farmers that grow various crops and fruits. The principle crops are coffee, maize, and beans, and the most commonly grown fruits are avocados, oranges, papayas, guavas, and bananas.

Design Process

Problem Framing Statement

Avocados in Leguruki are a plentiful resource but have very little value, selling for as little as 25 TZS per avocado when sold in bulk. They are under-utilized as well: their only perceived use is consumption, and so approximately 50% of avocados cannot be sold or eaten and consequently end up being wasted.

Value Proposition

We believe that avocado oil extraction will address many of the problems faced by villagers in Leguruki, as avocado is a versatile and high value product. As cooking oil, it is comparable to olive oil, both in cost and quality. It can also be used in cosmetics, such as soap, shampoo, and lotions. Currently, an average household in Leguruki spends 400 TSh on cooking oil per day, totaling 146,000 TSh per year. In the short-term, we believe that an avocado oil press will provide value by allowing households to extract their own oil and cut down on other cooking oil costs. In the long-term, we hope that Leguruki can access markets to sell the oil in, and also earn money from selling products made from processed avocado oil.

Summary of Design Process

Prior to the first visit to Leguruki, research was conducted on alternative uses of avocados and on other avocado producers. This research was important as it allowed us to gauge users' understanding of avocados and also to gauge users' interests in different processes.

Our first trip to Leguruki lasted 4 days and was centered on gathering information about users. Interviews with users typically lasted 15-20 minutes. The bulk of each interview focused on the user's current state with respect to avocado growing. This included asking about how many avocados they had, how they were harvested, what they did with the harvested (and not-harvested) avocados, and if they had heard of any other alternative uses. Contact info was taken down and users were invited to a community presentation, which was held on our last day.

After synthesizing the information gathered in the interviews, we framed the problem using a problem framing statement and tree. We then created sketch models, which we presented to the community on the last day. At the presentation, we gathered feedback on the sketch models to ensure that we would be working toward a solution that was desired by the community. The feedback was overwhelmingly in favor of creating an avocado oil press.

Upon returning to Leguruki, we began brainstorming ideas for extracting avocado oil. We simultaneously ran small experiments where we attempted to dry avocado. We finally settled on three ideas (hammer press, standing press, and jack press) and built prototypes for these ideas. We decided on three ideas rather than one so that we could get feedback on users' desired price-point, since we were unsure how users valued price and convenience.

Upon arriving in Leguruki, we procured avocado and laid it out on tarps to dry. The avocado was left out for three days, and rotted instead of dried. From this, we identified drying as a critical part of the oil extraction process that we would have to address.
In the mean time, we dried avocado by cooking it down and boiling off the water, which decreased the quality of the oil and also discolored it. We used the dried flesh to test our prototypes and demonstrate them to users. Feedback was again positive, but users were divided on price. One group, mostly men, were willing to pay upwards of 100,000 TSh for an oil press, and expressed interest in using it to create a small business. The other group, mostly women, quoted prices between 15,000-25,000 TSh.

After returning to Arusha, we again divided ourselves to create multiple prototypes. One prototype was a solar drier, and the other (lever press) was a different kind of oil press that used a long lever to increase the force provided by the user. During the prototyping process, we dried avocado in a solar drier that was kept at the workshop. We varied the drying process by cutting the avocado into pieces, rather than a mush. The result was mostly unsuccessful, as the pieces dried on the outside but not the inside.

Analysis and Experimentation

Oil Pressing

9 avocados were dried and then pressed, producing 340g of oil. The density of avocado oil (0.92g/ml) was taken from known data tables and used to calculate the volume of oil extracted per avocado: 41ml of oil per avocado.

Drying

We first attempted to dry mashed up avocado flesh while in Arusha. Our first test was a failure, due to unforeseen circumstances wherein wild dogs ate all of our avocado.

During the second test, mashed avocado was layered and placed in an oven to dry. The avocado mash was layered to include 4 different thicknesses. This test partially failed, due to unforeseen circumstances wherein the kitchen's chefs re-spread the avocado flesh to form a single, uniform layer. However, this test did allow us to validate that oil can be extracted from dried avocado using very little force (such as pressing the dried flesh between fingers).

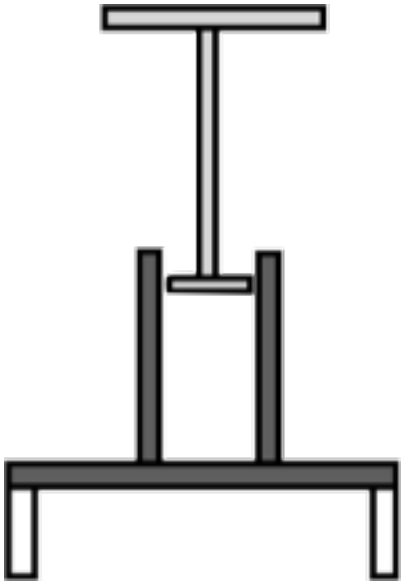
The third drying experiment was conducted in Leguruki. 20L of mashed up avocado was spread onto a 20 foot tarp and left to dry in the sun for 3 days. This test also failed to produce dried avocado, but succeeded in creating 20L of moldy, noxious-smelling, rotten avocado. Part of the reason this drying method didn't work was that Leguruki only gets around 4-5 hours of direct sunlight during the winter months (such as July) and otherwise is overcast and damp. This drying experiment was significant because it clarified the need for a drying technology.

When sun drying failed, we experimented with boiling mashed avocado. While effective, it discolors the oil and gives it an unpleasant taste. It is also requires a lot of time and fuel, which led us to conclude that cooking down avocado is not a long-term solution for oil extraction.

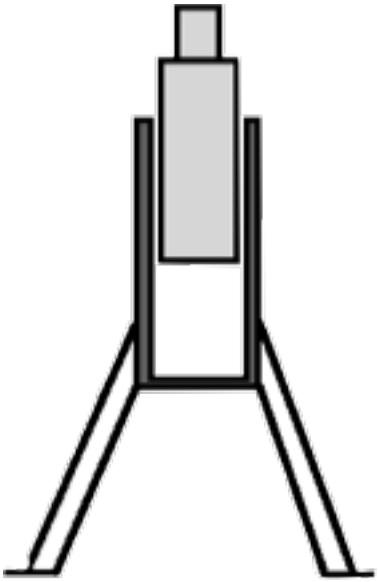
The final drying experiments were conducted in Arusha. Avocados were cut into pieces (large chunks the size of an orange slice, and smaller pieces approximately a third of the size of the larger chunks) and placed on trays inside of an up-draft solar dryer. These pieces were left to dry for three days. The pieces were dried on the outside, but did not sufficiently dry on the inside. Several were starting to get mild as well. Still, this experiment was promising because it

suggested that drying is feasible if adjustments were made to the drying technology and process.

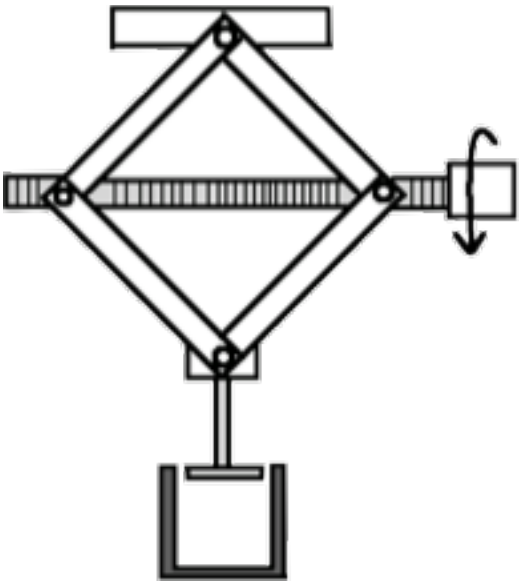
Prototypes



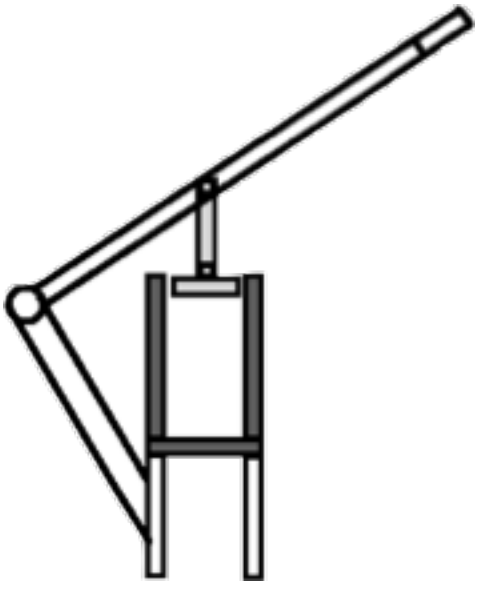
STANDING PRESS: User stands on base and continuously presses on handle using body weight.



HAMMER PRESS: User Hits slug with hammer repeatedly. Oil drips out through small holes in the base of the container.



JACK PRESS: User turns crank on scissor car jack continuously, which slowly lowers the press. The operation is simple and can generate up to 3 tons of force.



LEVER PRESS: User pulls on handle to lower press. Longer handles increase the user's leverage.

Design Requirements

Customer Needs	What are we going to measure	How are we Measuring (units)	Good Value	Better Value
Affordability	Cost of the machine	Shillings	<50,000	<30,000
Life Time	Strength of materials used	No. of operational hours	>1000 hours	>1500 hours
High Oil Production	Amount of oil pressed in 5 minutes	ml/min	200	500
	Amount of oil left unpressed	ml	50	0
Easy to use	Force by Users	pounds	100	50
	# of users required	number	2	1
Convenient	Time to clean/day	minutes/day	10	5
Safe	Exposed sharp edges	number	0	0
Produces Good Quality Oil	Debris in oil	# of particles per 100ml		0

How It Works

Drying

The solar drier prototype we built uses tarp and insulation to convect heat. The semi-transparent tarp creates a greenhouse effect, which heats the air inside the drier. Insulation at the bottom helps trap the heat in. The sides of the drier have openings to allow wind and air currents to remove the moisture-saturated air inside the drier.

One additional advantage of the plastic tarp is that it allows the material to be in direct sunlight. Research done on evapotranspiration of grass canopy beds suggests that direct solar radiation is the most important factor in drying (rather than wind speed, humidity, or temperature).

http://members.efn.org/~itech/pdf%20files/Solar%20tunnel%20food%20dryer.pdf
http://www.aee-intec.at/0uploads/dateien553.pdf

Oil Presses

Each oil press operates on a similar principal. All of them attempt to create large amounts of pressure on the dried avocado flesh, forcing the oil out. Channels, grooves, or coarse filters were incorporated into each design to provide a path for the oil to be removed from the system.

Performance

Press	Quantity Extracted	Extraction Speed	User Friendliness	Cost
Standing	0	0	0	0
Hammer	—	0	—	0
Jack	+ +	—	+ +	— —

Note: Lever press not included due to insufficient time for testing

The performances of the three initial press prototypes are compared above. The jack press scored highest overall, due to its higher output and ease of use. However, it was slower and much more expensive (which could potentially restrict potential users from purchasing the product).

The standing press and hammer press functioned similarly, but the standing press performed better because the user could use their body weight to extract the oil.

The testing of the solar dryer prototype has not been completed at the time of this writing (9/8/14).

Bill of Materials

Jack Press

Material	Quantity	Approximate Cost
Car Jack	1	55000
1” flat bar	10’	9000 (12000 for a 4m piece)
1.5” angle iron	20”	3000 (25000 for a 4m piece)
1/8” steel plate	1 3”x3” piece	

Self-Assessment

Financial

The prototypes that we have created give us a broad range of flexibility, allowing us to select a prototype that addresses the needs of even our most financially constrained users. Affordability and income-generation are two of our most important considerations when considering how to proceed, and we are exploring different ways that users could mutually benefit by combining resources.

The drying process is still undetermined. It is likely to add a significant cost to the project, however we are still determining how that cost changes when the dryer size is scaled.

Technical

Our prototypes are not fully developed technically. In part, this is because we are still continuing the conversation on what users want out of a machine (we expect it to be mainly cost-driven). Once we and users have settled on a more specific technology, we can begin addressing the technical concerns. As oil presses are mature technologies, we believe the technical concerns can be addressed, even with the design constraints we face.
The drying prototypes are also not fully developed technically. Like oil presses, driers are well-studied technologies. While we believe that avocado drying is technically feasible, we face the challenge of adapting drying technology to be low-cost. Further testing has to be done on our existing prototypes to determine if they meet the technical specifications.

Social and Cultural

None of our user research indicates that our technologies will face social or cultural barriers. Users were excited about it and willing to try our prototypes.
Our project is impacted by cultural and social norms in one primary way: avocado growing as handled primarily by women, however men do all of the harvesting and men also own the larger avocado farms. We have addressed this by creating a range of prototypes that suit the needs of the different groups. We plan to involve both women and men when deciding how to proceed with the project, and discuss how we can choose a technology that can benefit both groups.

Environmental Sustainability

We expect that the oil presses and drier that we are designing will have little impact on the surrounding environment of Leguruki. These technologies use small amounts of material, and can be shared amongst groups of people.
The biggest potential impact that we can have on the environment is by changing the avocado growing habits in the region. Avocados require a lot of nutrients to produce, and large-scale avocado farming could sap nutrients from the soil and change the soil's fertility. While we are aware of this possibility, we do not believe it is reason enough to stop the project.

Lessons Learned

Community Engagement

- Begin by explaining what you're doing - don't jump straight to questions
- Allow time for small-talk and casual questioning
- Don't spend too long talking to the same person
- Photographs are a nice gift to give people who you work with and talk to
- Speak in Swahili whenever possible
- Speak to people in groups

User Feedback

- Talk to as many people as you can
- Do background research, but don't let that guide the conversation
- Don't ask questions that can narrow the scope of ideas.
- Be open to ideas, even if you expect them not to work
- Prepare questions in advance, but leave them flexible

Troubleshooting

- Try to finish all prototyping before traveling
- Have back-up plans for when a prototype fails
- Failed, broken, or dysfunctional prototypes are still useful for demonstrations

Project Continuity

Reflection on Project Viability

We believe that this project is viable to continue post-IDDS. Although a final prototype direction has still not been decided, there is a promising amount of momentum from both the IDDS team and the community partners that were engaged during IDDS.

Support from Leguruki for this project is critical to its success. During the final day in Leguruki, the team sat down with nine members from Leguruki village and the surrounding area to discuss the project continuity. The group expressed strong interest in seeing the project continue, and suggested forming groups of avocado farmers (currently, no such groups or cooperatives exist for avocado farmers in Leguruki). During the final days at IDDS, we again spoke with two of community members from Leguruki. We worked with them to form a 6-month plan for continuity and discussed how these farmer groups could possibly be formed.

The project also benefits because three of the five team members (Elliot, Anna, and Steven) live in either Arusha or Leguruki, and thus are close enough to directly work on the project. The next step for the project is to have these three team members return to Leguruki and attempt to meet with the group of farmers.

Another factor that contributes to the project's viability is the involvement of ECHO, IDIN's community partner in Arusha. ECHO already does work with avocados, including grafting different trees together, which is a technique that farmers in Leguruki are very interested to learn. We hope that ECHO can be involved in helping facilitate conversations with the village of Leguruki and also help disseminate knowledge throughout the region.

There is currently no official government support for the project, as the agricultural office has no involvement with any avocado production. However, the village and ward mtendajis were very interested in seeing the project continue. This suggests that it may be possible to get the local government's support in establishing farmer groups and arranging community meetings. We hope that the benefits of this project and the benefits of partnering with ECHO will help lead to increased governmental support for this project's continuity and for avocado producers in the area.

Dissemination Model

We plan to disseminate the oil press technology by freely sharing the design, either with manufacturers or with established groups of avocado growers (or potentially with both). This dissemination model may change slightly depending on the design that is chosen — since our goal is to identify an appropriate oil extraction process rather than create a new kind of oil press, it is possible that the project may continue by connecting farmer groups to existing oil press manufacturers.

The biggest challenge when using this dissemination model will be to establish channels of communication that will help encourage the sharing of the technology. When establishing our first group of Leguruki avocado growers, we plan to select members from other farming groups and cooperatives around the region. We hope these members will then return to their other farming groups to share the technology. Furthermore, we hope that by sharing the design with local

manufacturers, they will have an incentive to fabricate presses and distribute them to other communities, consequently extending the project's impact.

6-Month Plan

Month	Avocado Team	Community
August	Funding & Research	Group Forming
September	Prototyping	Identifying 3 members from the community who will work with the team hands on.
October	Prototyping refinement	3 members join the team
November	Community visits with the Prototypes	Arranging the meetings, prototype demonstrations, Liaising with the local Govt. for support in the project.
December	Further Refinement of prototype	To work with the team
January	Dissemination and transfer of technology	To adapt the technology and build machines for oil press

Anticipated Risks and Challenges

The project's biggest unknown is the drying process. As discussed earlier, the team needs to conduct further testing and experiments.

Another challenge for the team will be coordinating contact with groups of avocado growers in Leguruki. Fortunately, the team has contact information for several growers in Leguruki, as well as one team member on the ground.

Another major challenge is ensuring that there are adequate resources to continue the project. Financial constraints could restrict travel and prototype building, and time constraints could limit or slow progress in the upcoming months.

Stakeholders

As we see avocado not just as a fruit, but also as a yield from which several other products can be made. We also anticipate having a value addition by processing avocados for other products. This scope and the nature of the project interests and influences several people that could be stakeholders of our project. Some of the stakeholders we identified are:

Avocado growers

This group of people would form the key stakeholders and are very important for the success of the project as they grow avocados; the interest levels and influence of these people will be very high in the project as any value addition to avocados would yield them good profits.

Consumers

Avocado consumers who upon realizing the various benefits of the cooking oil from avocados and other products that can be made from products; can change the consumption pattern and help in creating a market for avocado cooking oil.

Avocado Oil Producers

This set of people and groups have interest in this project as pressing oil from avocados can fetch some money and it can also be consumed as cooking oil.

Contact Information

Community Partners

Local Government

The village and ward mtendajis (chairmen) were both very receptive to the project. We also made contact with the agricultural officer, Mary, who is not involved with the project but could possibly be convinced to play a role.

Mama Shedrack

A local avocado grower named Mama Shedrack lives close to the town center and attended the final prototype presentations at Nane Nane as one of the team's invited guests.

Pastor Emmanuel and Jeremiah

Pastor Emmanuel is one of the largest avocado producers in the Leguruki district. He has his own wood workshop, and has held classes on avocado growing at his church.
Jeremiah is a friend of the pastor, and attended our final presentation at Nane Nane on the pastor's behalf.

Appendix A - Selected Photos

DRIED AVOCADO FLESH

STANDING PRESS PROTOTYPE

ANNA USING THE STANDING PRESS PROTOTYPE

ELLIOT SPREADING AVOCADO FOR SUN DRYING

SUN DRIED AVOCADO THREE DAYS LATER

BOILING OFF WATER FROM AVOCADO

AVOCADO FLESH AFTER THE WATER IS BOILED OFF

PRESSED AVOCADO FLESH

AVOCADO OIL

CLOGGED OUTLET HOLES IN THE HAMMER PRESS

PASTOR EMMANUEL

THE TEAM WORKING WITH PASTOR EMMANUEL

PASTOR EMMANUEL USING THE JACK PRESS

AVOCADO PIECES DRIED ON THE OUTSIDE

AVOCADO PIECES DRIED ON THE OUTSIDE

THE TEAM PRESENTING BEFORE NANE NANE